Phytoplankton Production and Distribution on the Grand Banks of Newfoundland in September 1985

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March 1988

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Canadian Data Report of Fisheries and Aquatic Sciences

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Les numéros 1 à 25 de cette série ont été publiés à titre de Records statistiques, Service des pêches et de la mer. Les numéros 26-160 ont été publiés à titre de Rapports statistiques du Service des pêches et de la mer, Ministère des Pêches et de l'Environnement. Le nom de la série a été modifié à partir du numéro 161.

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Fisheries and Aquatic Science No. 691

March 1988

PHYTOPLANKTON PRODUCTION AND DISTRIBUTION ON THE GRAND BANKS OF NEWFOUNDLAND IN SEPTEMBER 1985

by

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Abstract

Irwin, B., Harrison, W.G., Anning, J., Caverhill, C., Dickie, P. and Platt, T. 1988. Phytoplankton production and distribution on the Grand Banks of Newfoundland in September 1985. Can. Data Rep. Fish. Aquat. Sci. No. 691: iv + 82 p.

During the period 3 September to 13 September 1985, a series of primary productivity experiments was conducted on board CSS Dawson on the Grand Banks of Newfoundland. In this report we make available the raw data and also the fitted light saturation parameters.

Résumé

Irwin, B., Harrison, W.G., Anning, J., Caverhill, C., Dickie, P. and Platt, T. 1988. Phytoplankton production and distribution on the Grand Banks of Newfoundland in September 1985. Can. Data Rep. Fish. Aquat. Sci. No. 691: iv + 82 p.

Pendant la période du 3 septembre au 13 septembre 1985, une série d'expériences de la production primaire a été effectuée au bord du CSS Dawson sur les "Grand Banks" de Terre Neuve. Dans ce rapport nous presentons les données brûtes ainsi que les paramètres calculés.

CONTENTS

Abstract/Résumé iii

Introduction 1

Sampling 1

Methods 1

Productivity 1

Chlorophyll *a* 2

Nutrients 2

Incubation light 2

Estimation of Photosynthetic Parameters 2

Acknowledgements 4

References 5

Introduction

This cruise was the final OERD Grand Banks Ecosystem study cruise. The overall objectives of the programme have been to study the distribution and growth dynamics of the microplankton (phytoplankton, zooplankton, bacteria) on the Grand Banks to develop an ecological model of the Grand Banks Ecosystem. In this report we present data on the distribution of inorganic nutrients and chlorophyll and the assimilation rates of the phytoplankton population.

Sampling

Water samples were collected with a modified continuous pump sampler (Irwin et al. 1985). Inorganic nutrients, chlorophylls and particulate carbons were collected at standard oceanographic depths in the upper 100m of the water column where depths permitted. Samples for PI experiments were selected from physical or biological features eg. chlorophyll maxima, bottom of mixed layer.

Methods

Productivity

Primary productivity was measured using the ^{14}C method essentially as described by Strickland and Parsons (1972). For light saturation experiments 20 µci of sodium bicarbonate ^{14}C was added to 100 mls of sample. A total of 42 light and 2 dark bottles were filled for each light saturation experiment. Incubations were done in temperature controlled incubators illuminated by 250 w tungsten halogen lamps [Gilway Technical Lamp L 7391]. All experiments were incubated for 3 hours. All samples were filtered onto Whatman GF/F filters.

Chlorophyll a

Replicate 100 ml samples were filtered onto 25 mm Whatman GF/F glass fibre filters. Filters were then placed in 20 ml glass vials containing 10.0 mls of 85% acetone. Chlorophyll was extracted for 24 hours at 0°C in the dark. The fluorometric technique of Yentsch and Menzel (1963) as modified by Holm Hansen et al. (1965) was used to estimate chlorophyll and phaeophytin concentrations.

Organic Particulates

Samples for particulate organic carbon and nitrogen were filtered onto precombusted Whatman GF/F filters. Filters were stored frozen for later analysis in methods described in Irwin et al. (1982).

Nutrients

Samples for nitrate, silicate and inorganic phosphate were collected from all sampled depths. Vials were stored frozen at -20°C and later analysed in the laboratory using a Technicon II Autoanalyser. Nitrate was measured using industrial method 158-71W, silicate with method 186-72W and phosphate with method 155-71W.

Samples for ammonia analysis were collected at selected stations. Ammonia concentrations were estimated using the phenolhypochlorite method of Solorzano (1969). Samples were analysed immediately after collection.

Incubation light

Photosynthetically Active Radiation (P.A.R.) was measured at each bottle position in the incubators with a Biospherical Instruments 4π quantum meter (Model Q.S.L. 100).

Estimation of Photosynthetic Parameters

Measurements of specific production P^B and irradiance I were used to estimate parameters in the equation of Platt et al. (1981).

$$P^B = P_S (1 - e^{-\alpha I/P_S}) e^{-\beta I/P_S}$$

P_S (mg C mg chl^{-1} h^{-1}) is the light saturated rate of specific production in the absence of photoinhibition, α (mg C(mg chl^{-1}) h^{-1} w^{-1} m^{-2}) is the initial slope of the PI curve and β (same units as α) is a parameter that characterizes photoinhibition. Complete details of the fitting routine are given in Irwin et al. (1982) and a discussion of the mathematical basis for this technique is in Irwin et al. (1980).

Acknowledgements

We wish to thank Alastair Macdonald for his assistance in preparing the data tables for this report, Mark Hodgson for the nutrient analysis and Madhu Paranjape for the collection of some of the samples.

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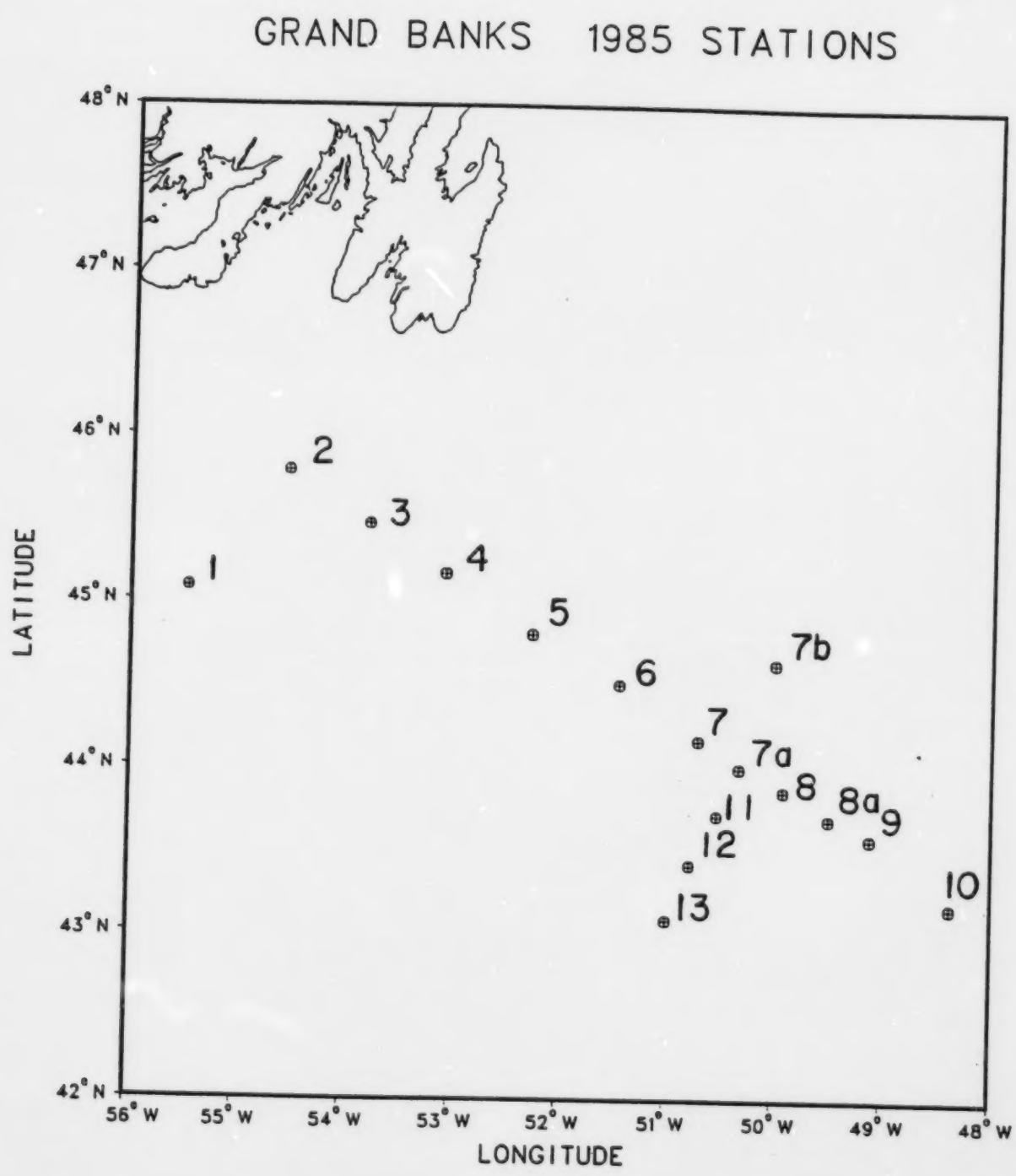

LOCATION OF SAMPLING STATIONS

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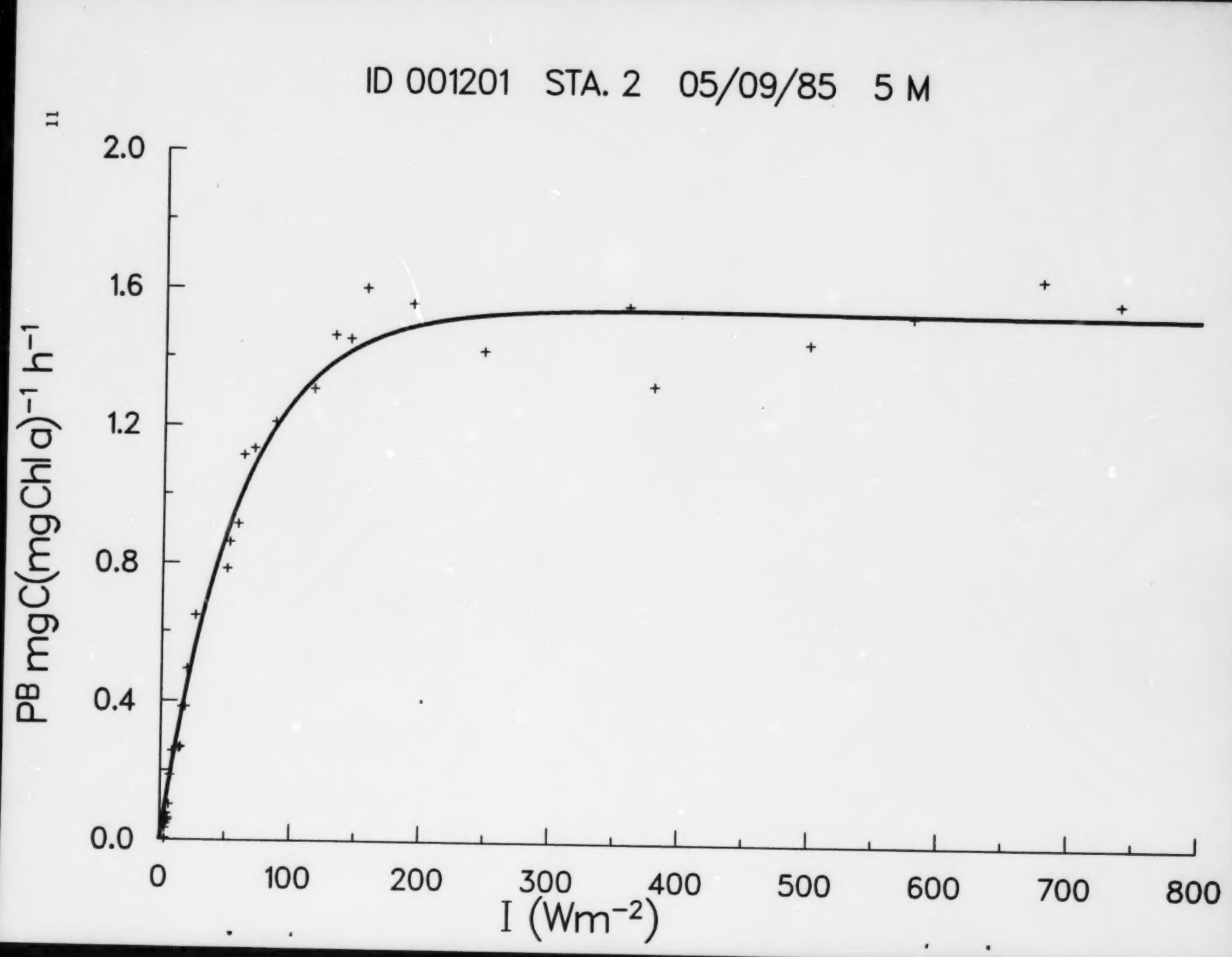
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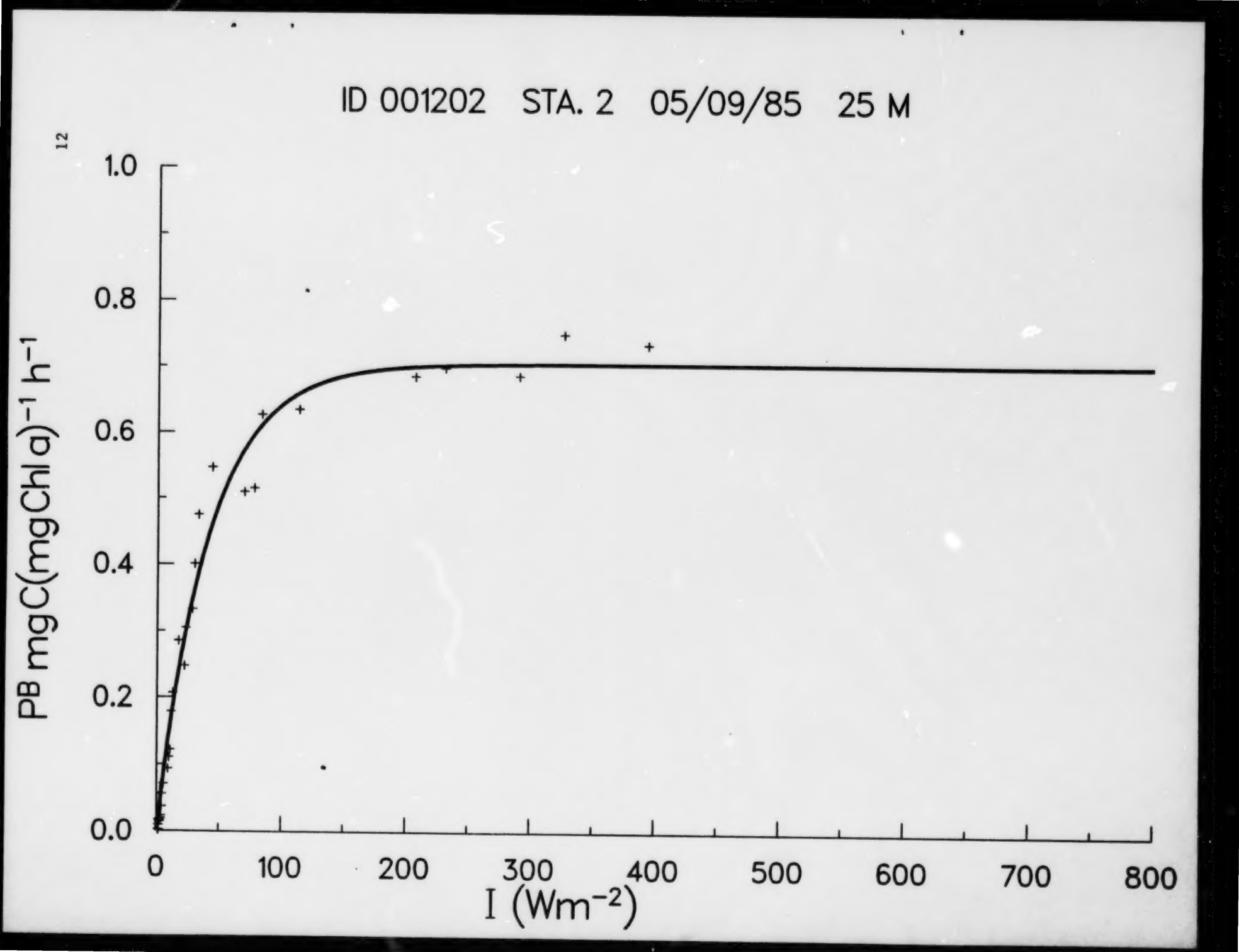
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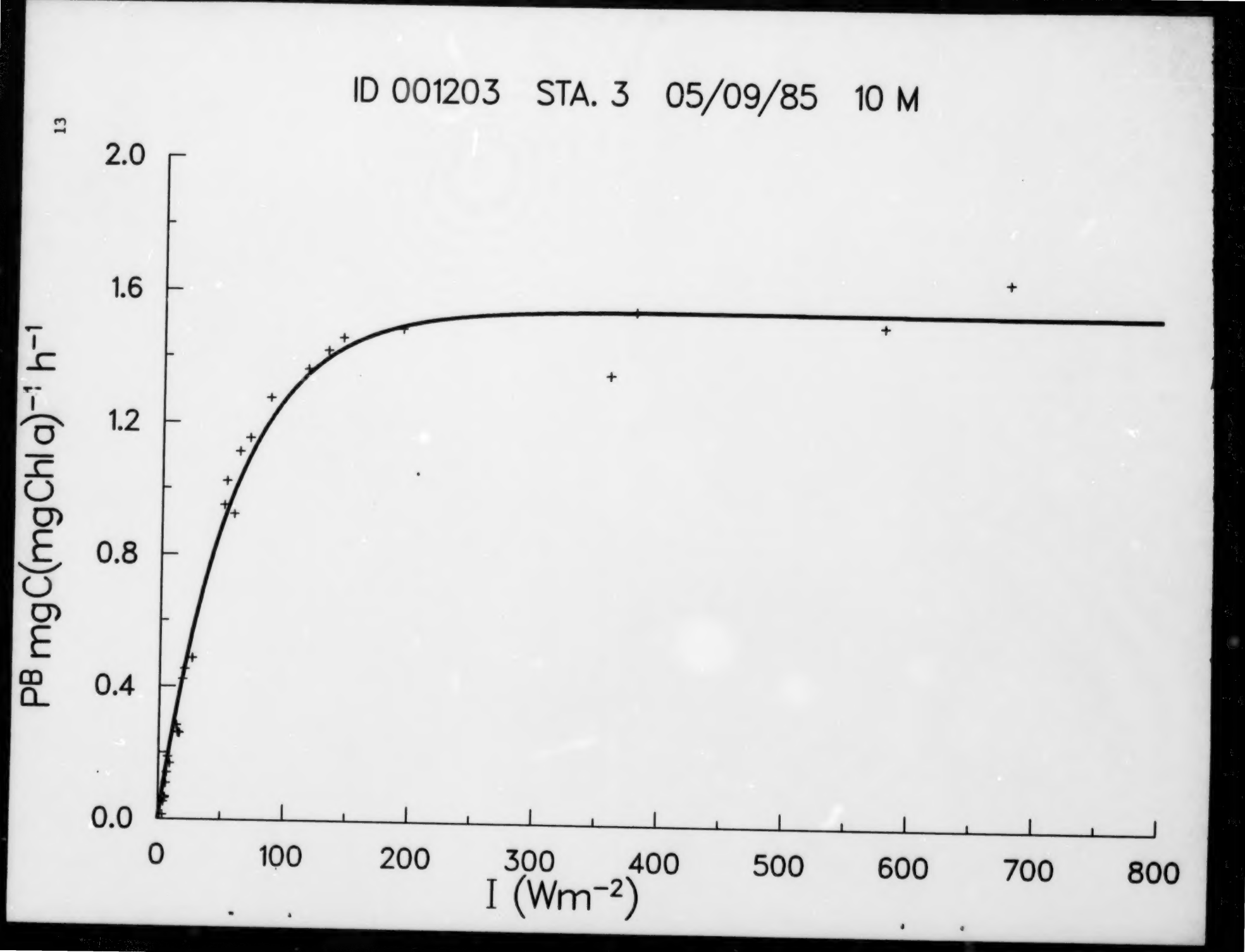
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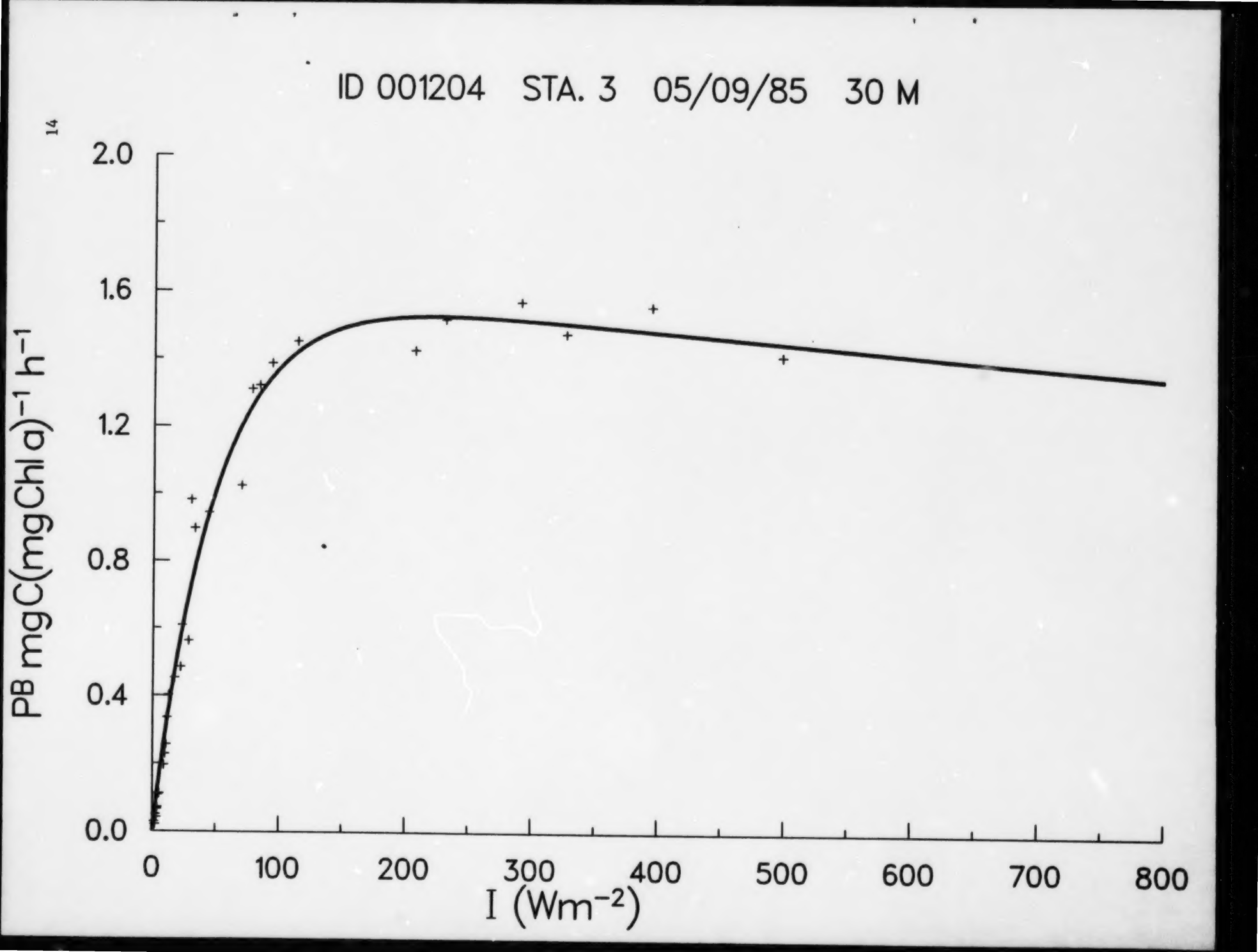
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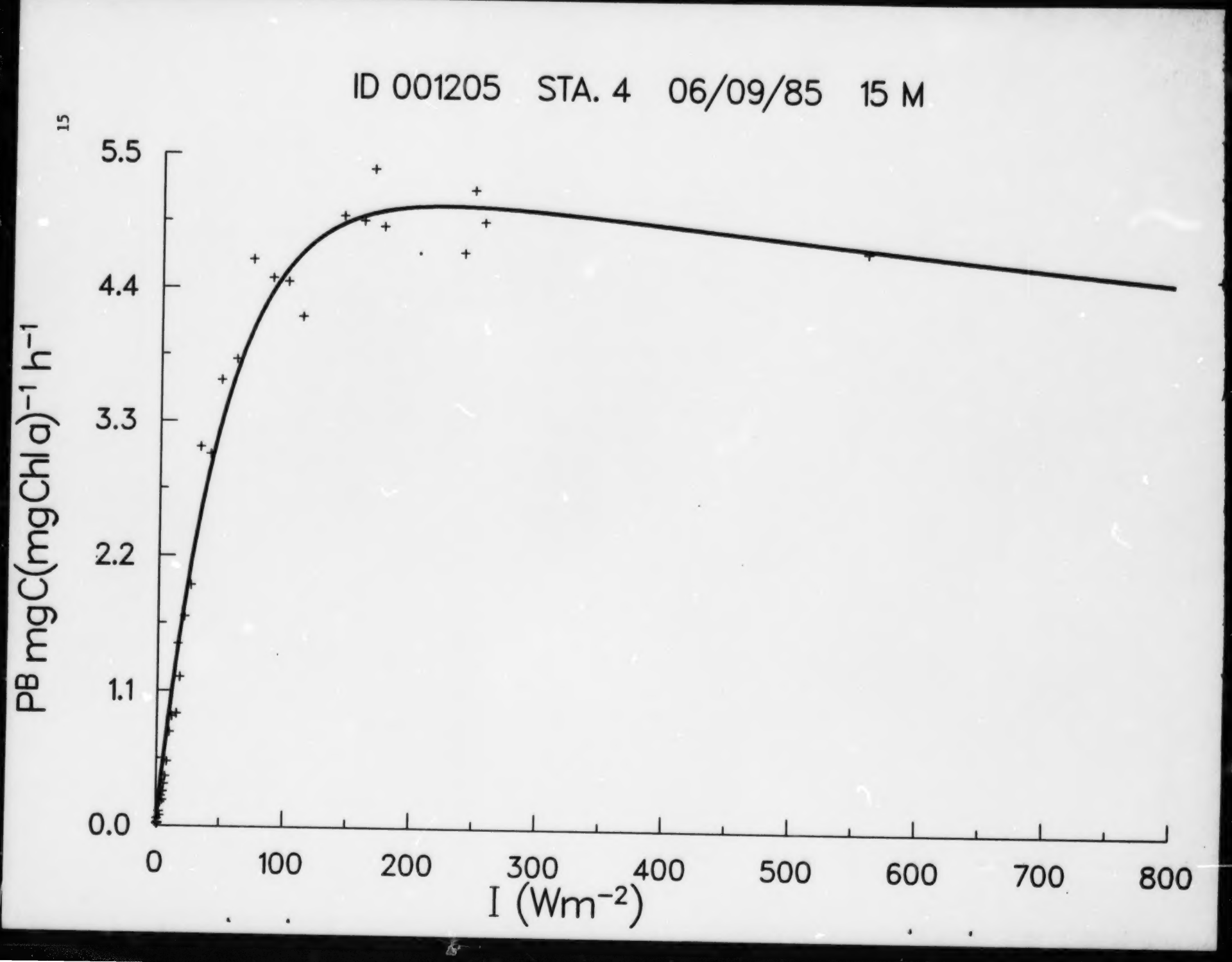
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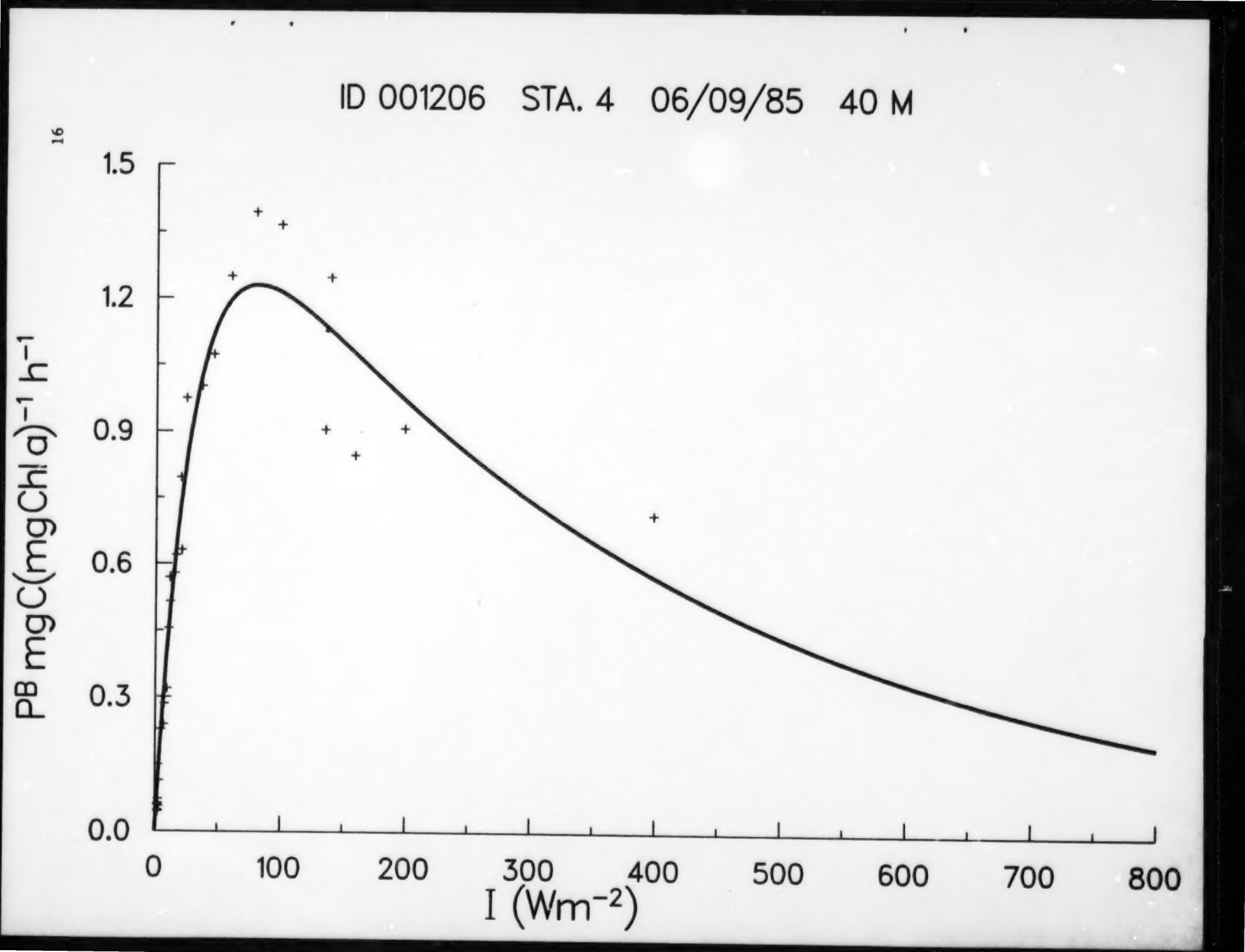
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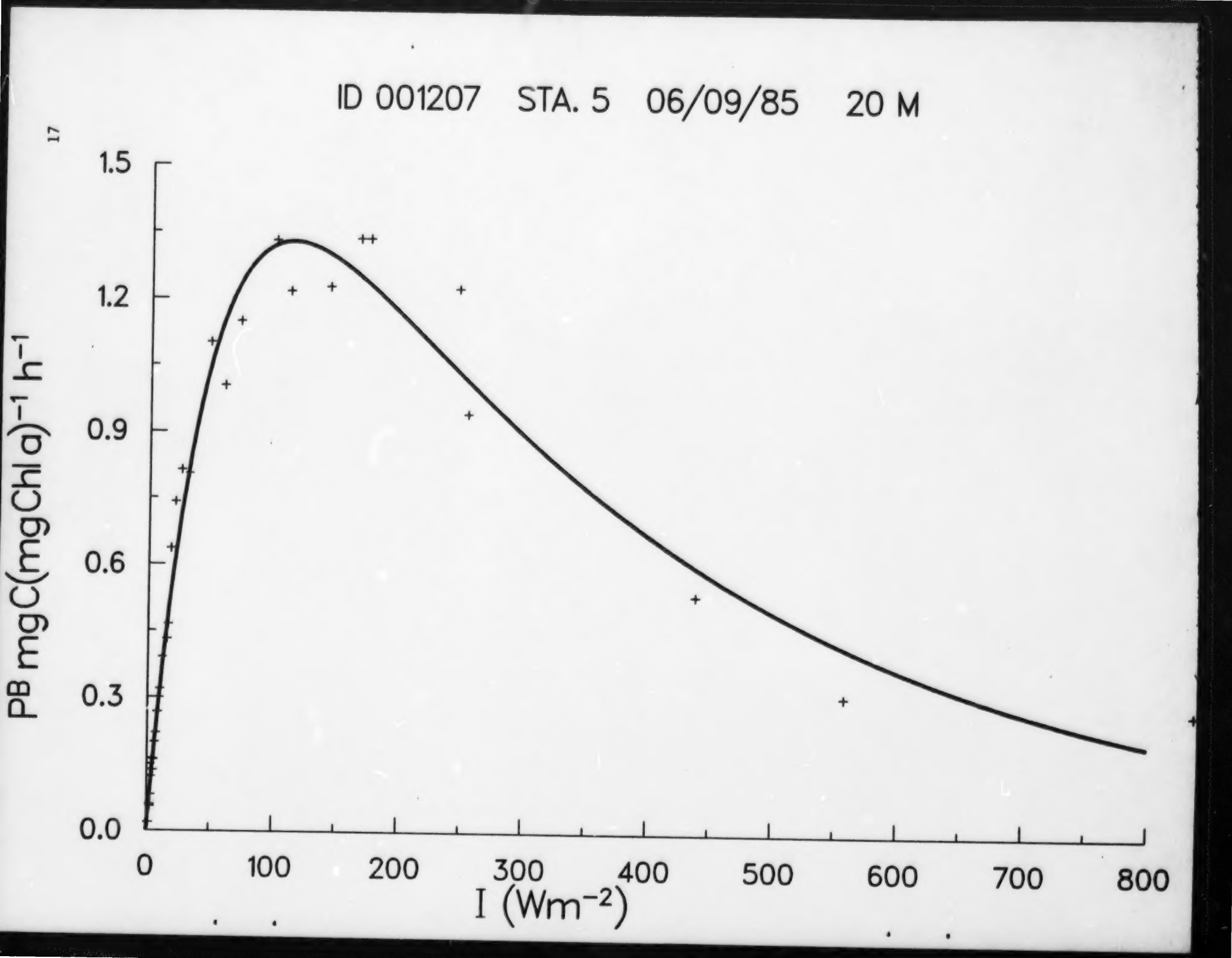
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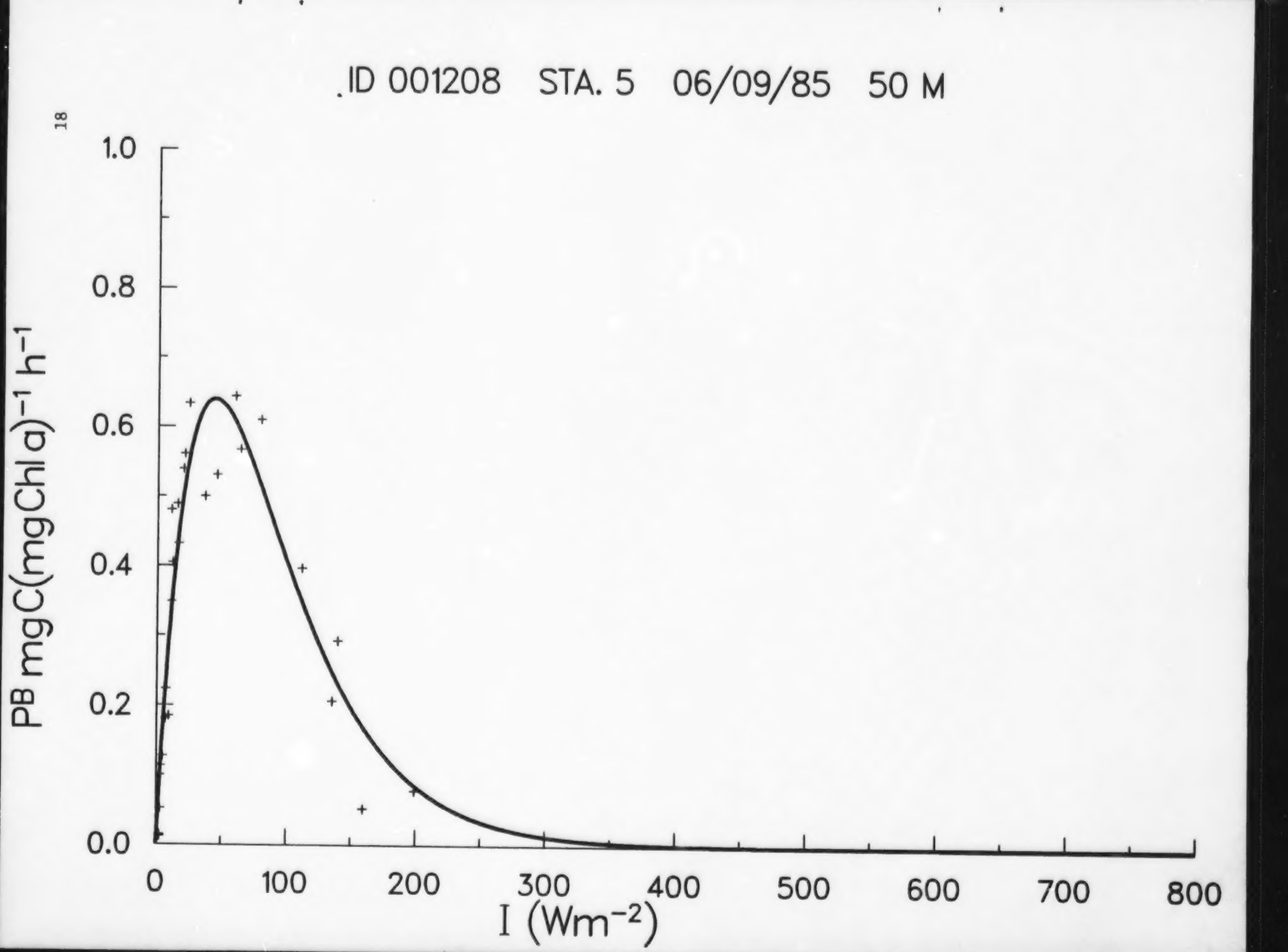
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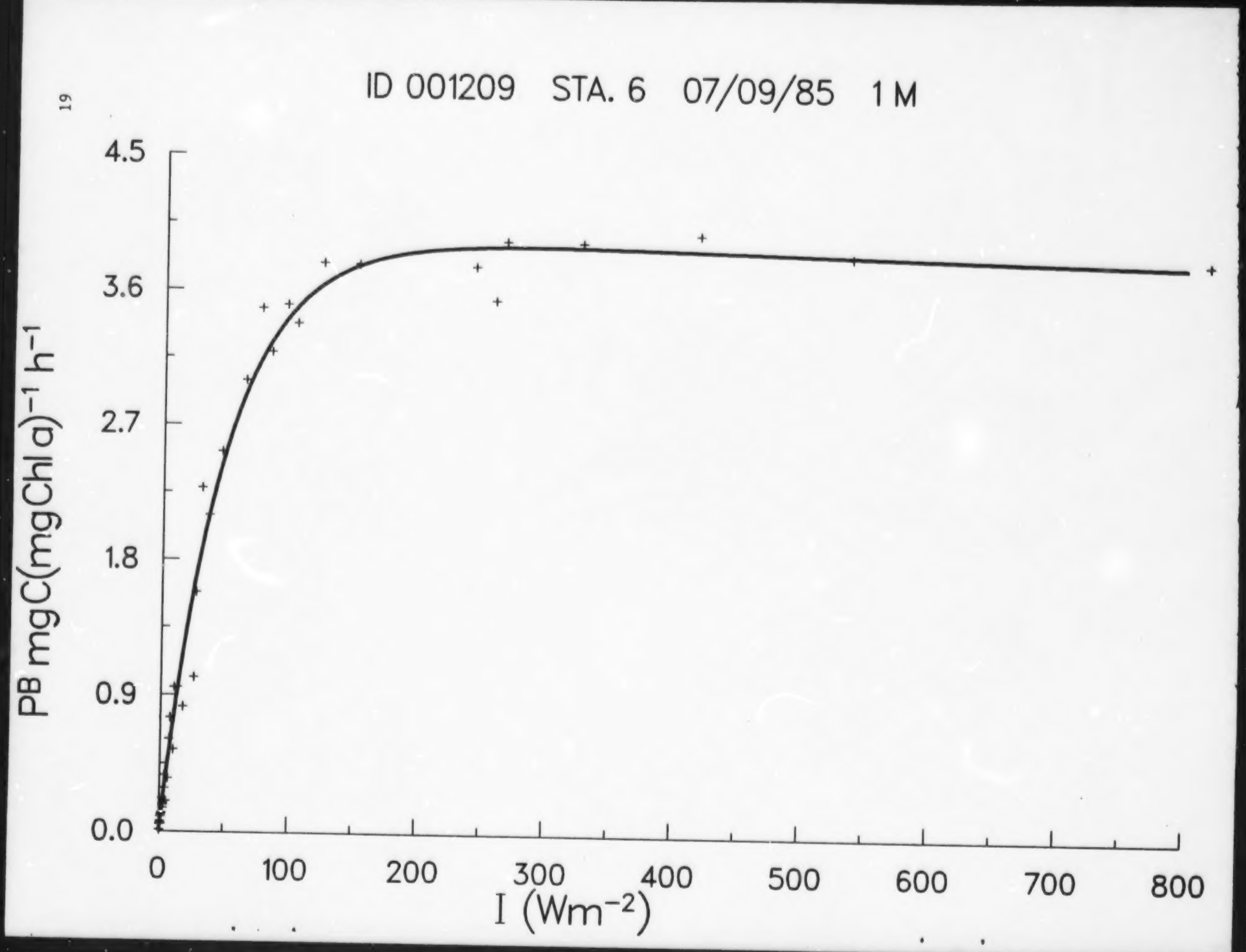
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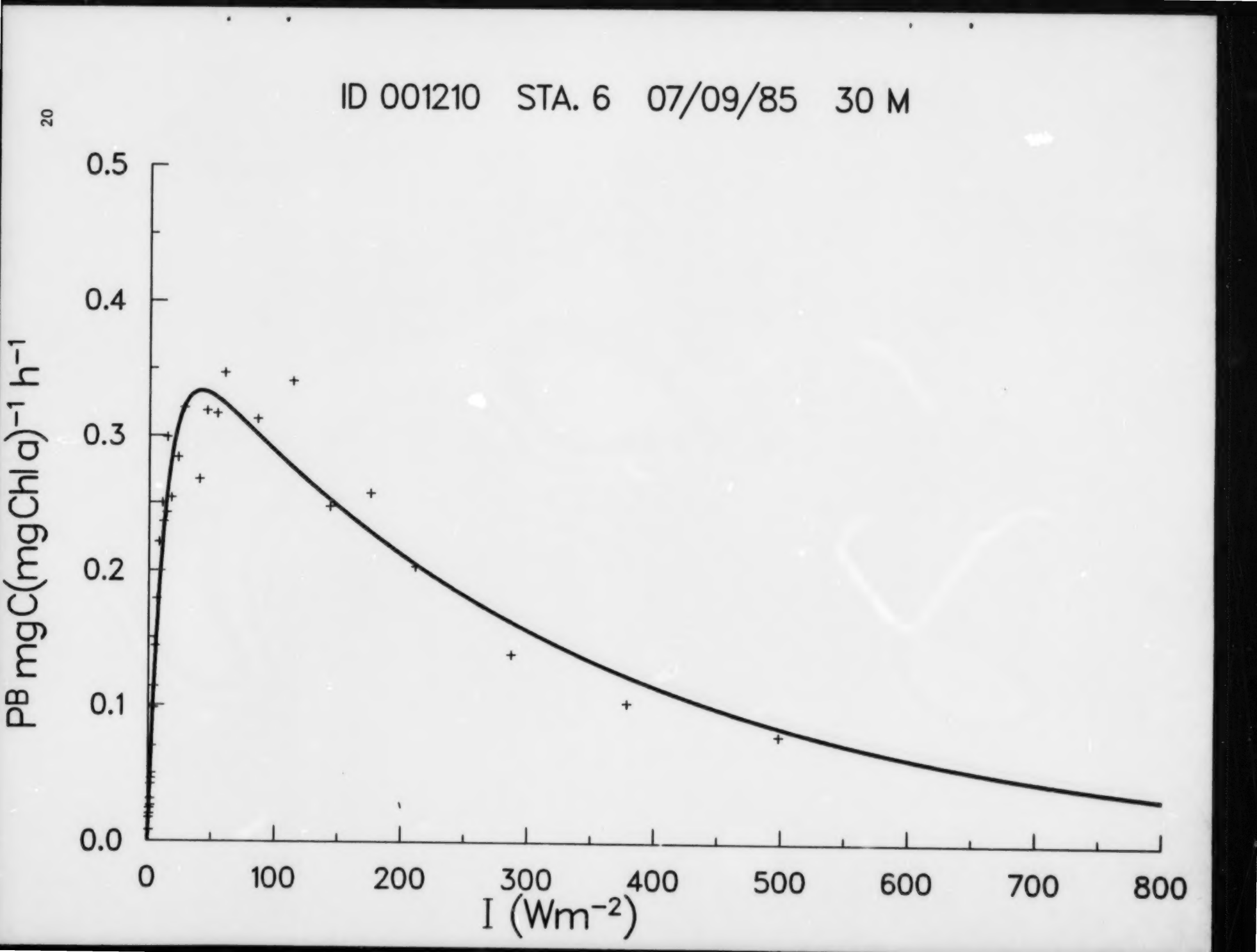
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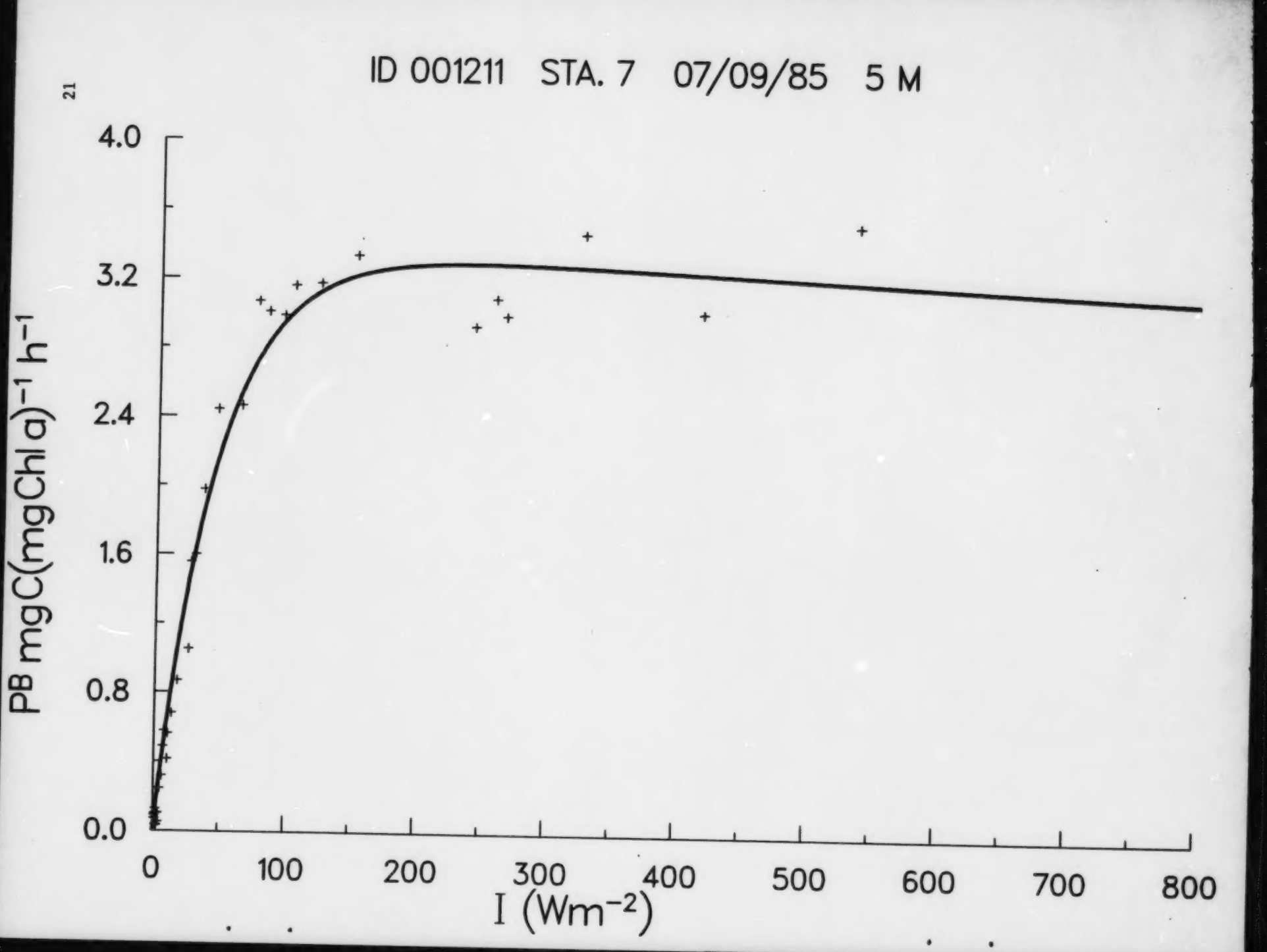
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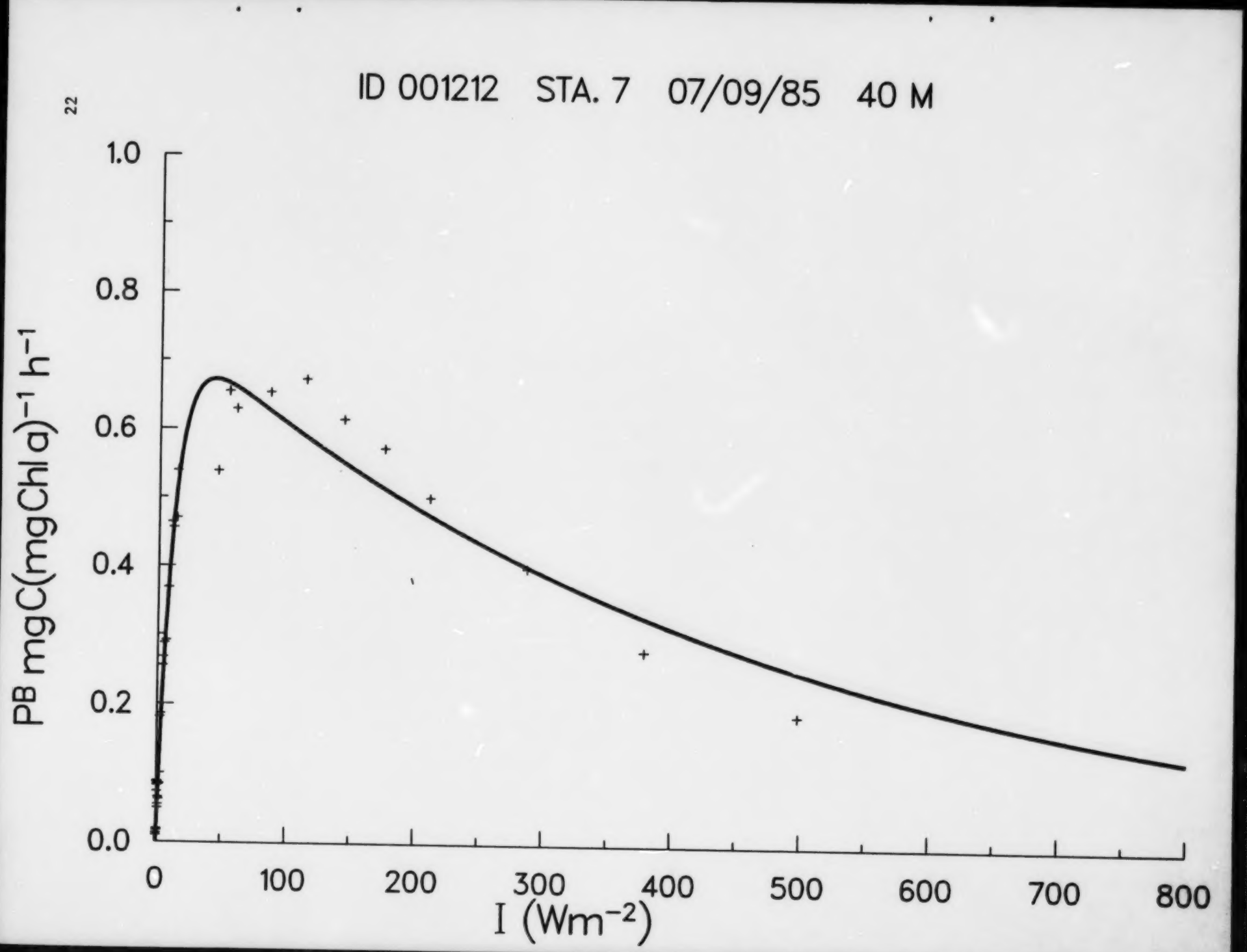
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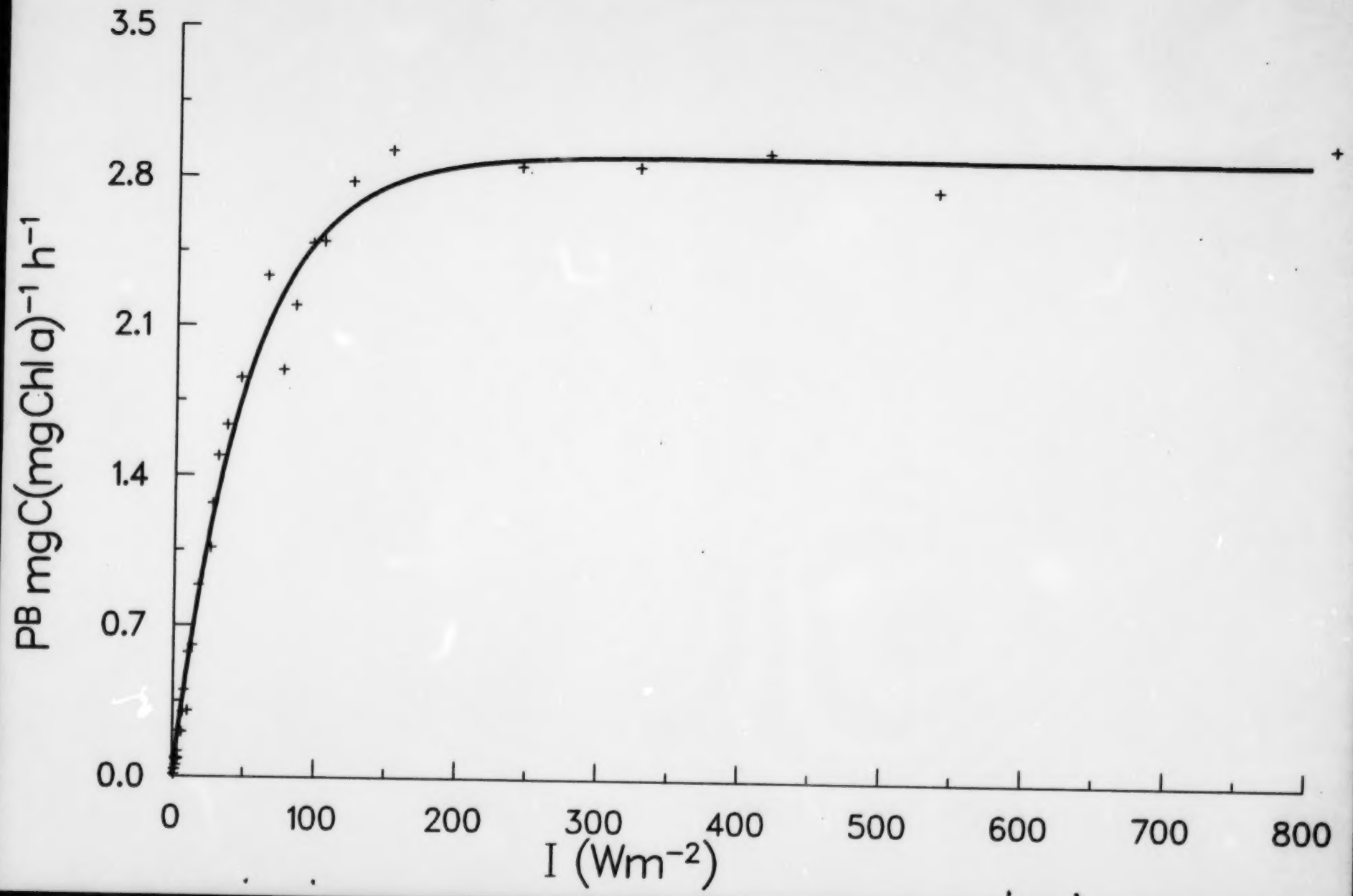

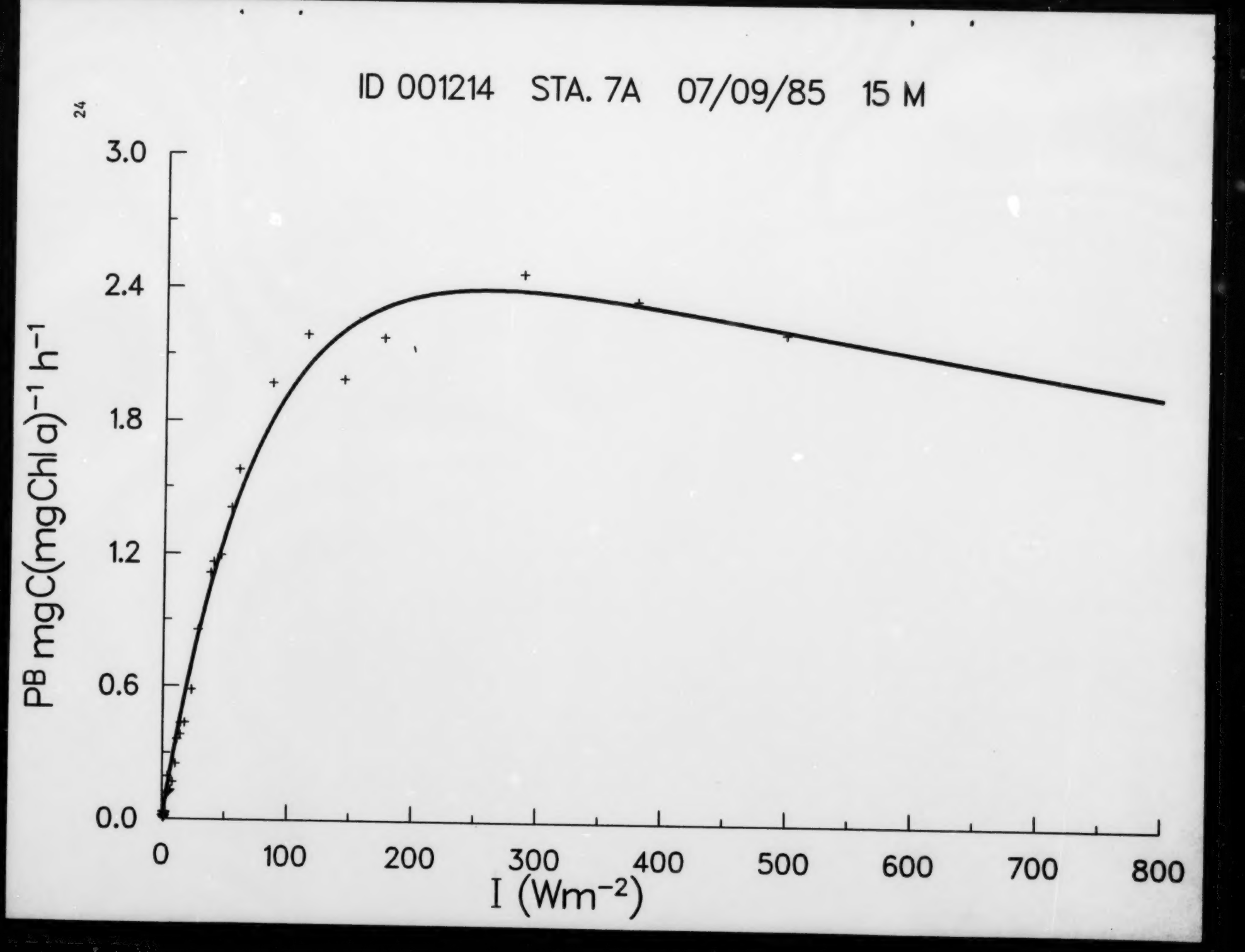
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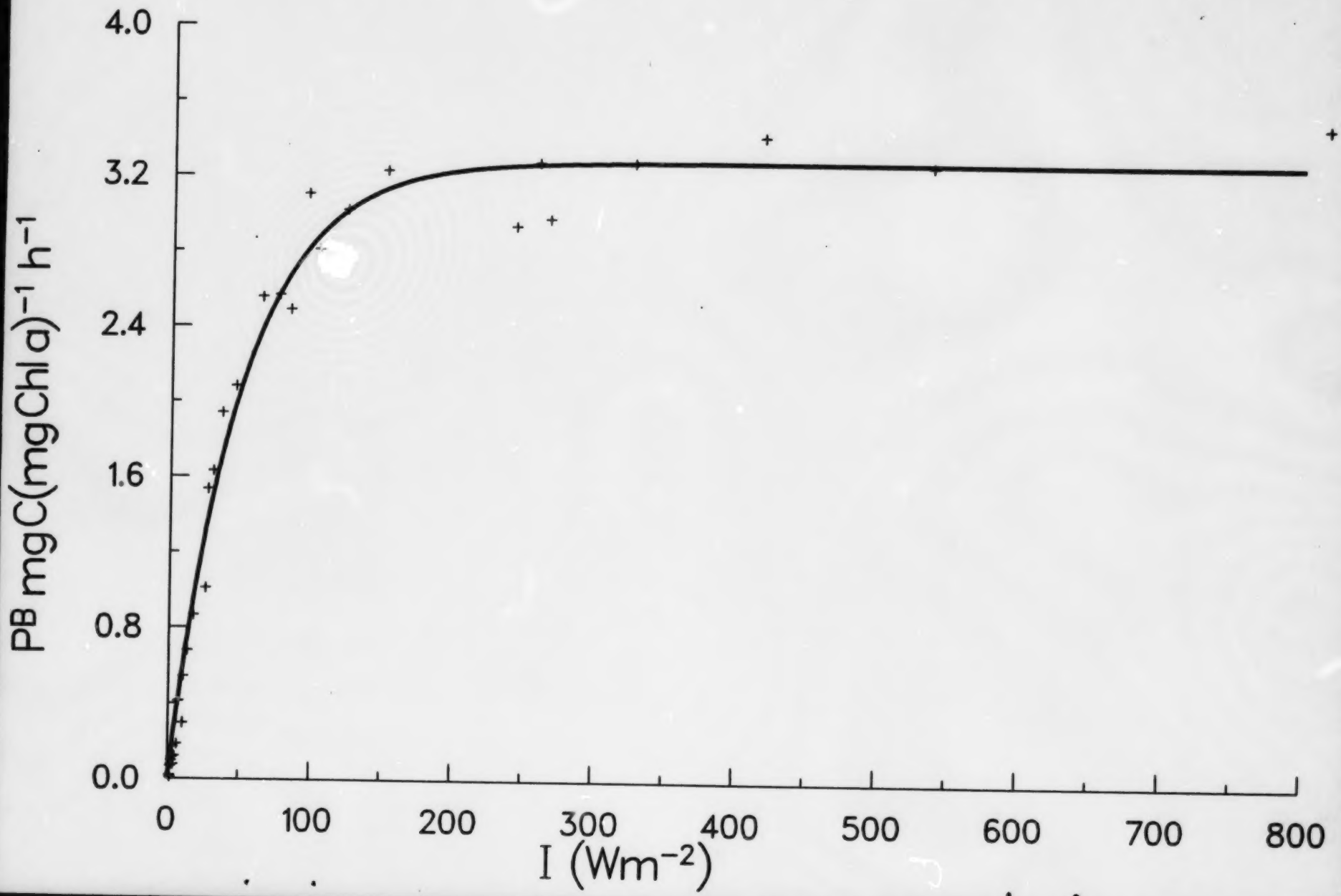

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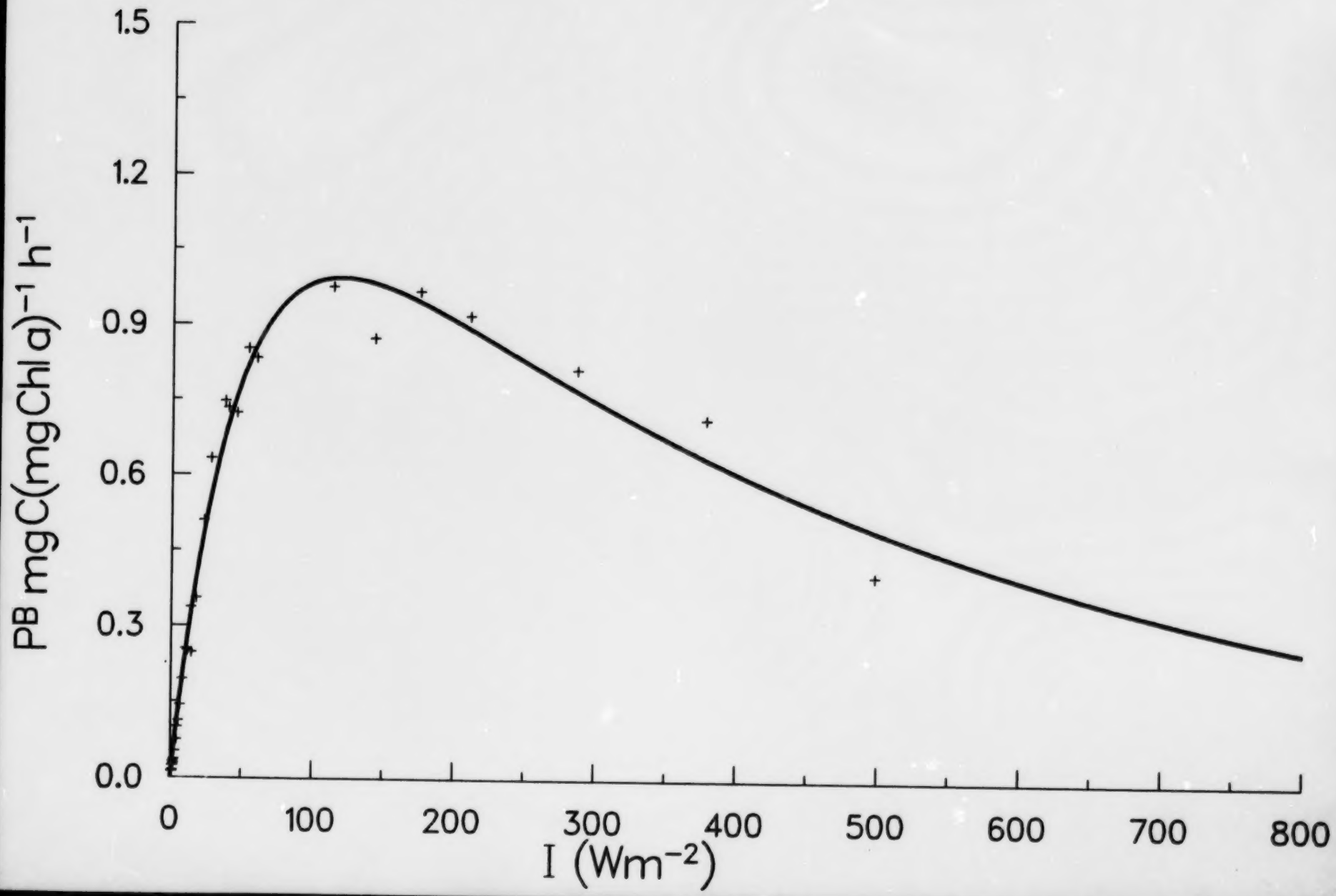

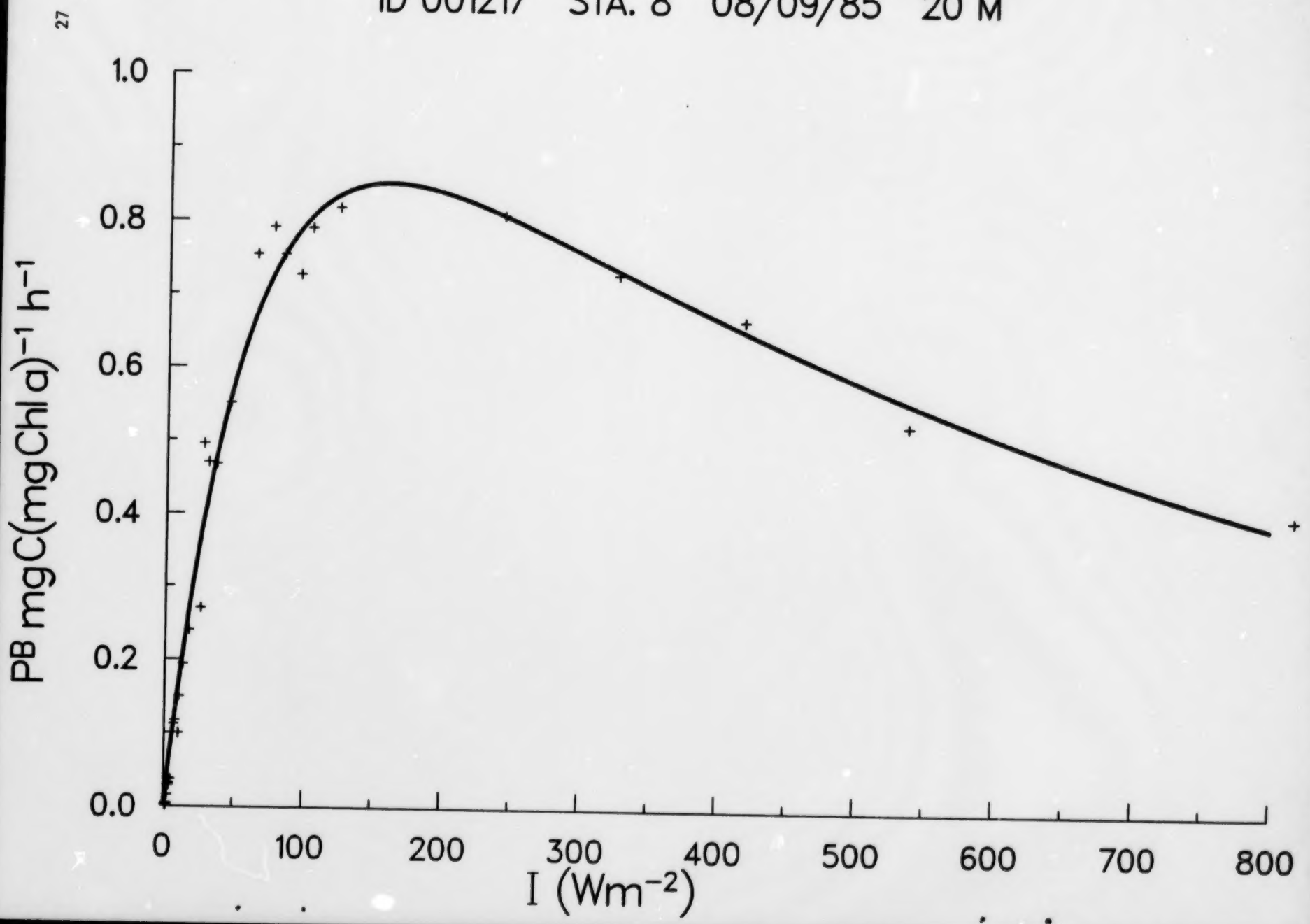
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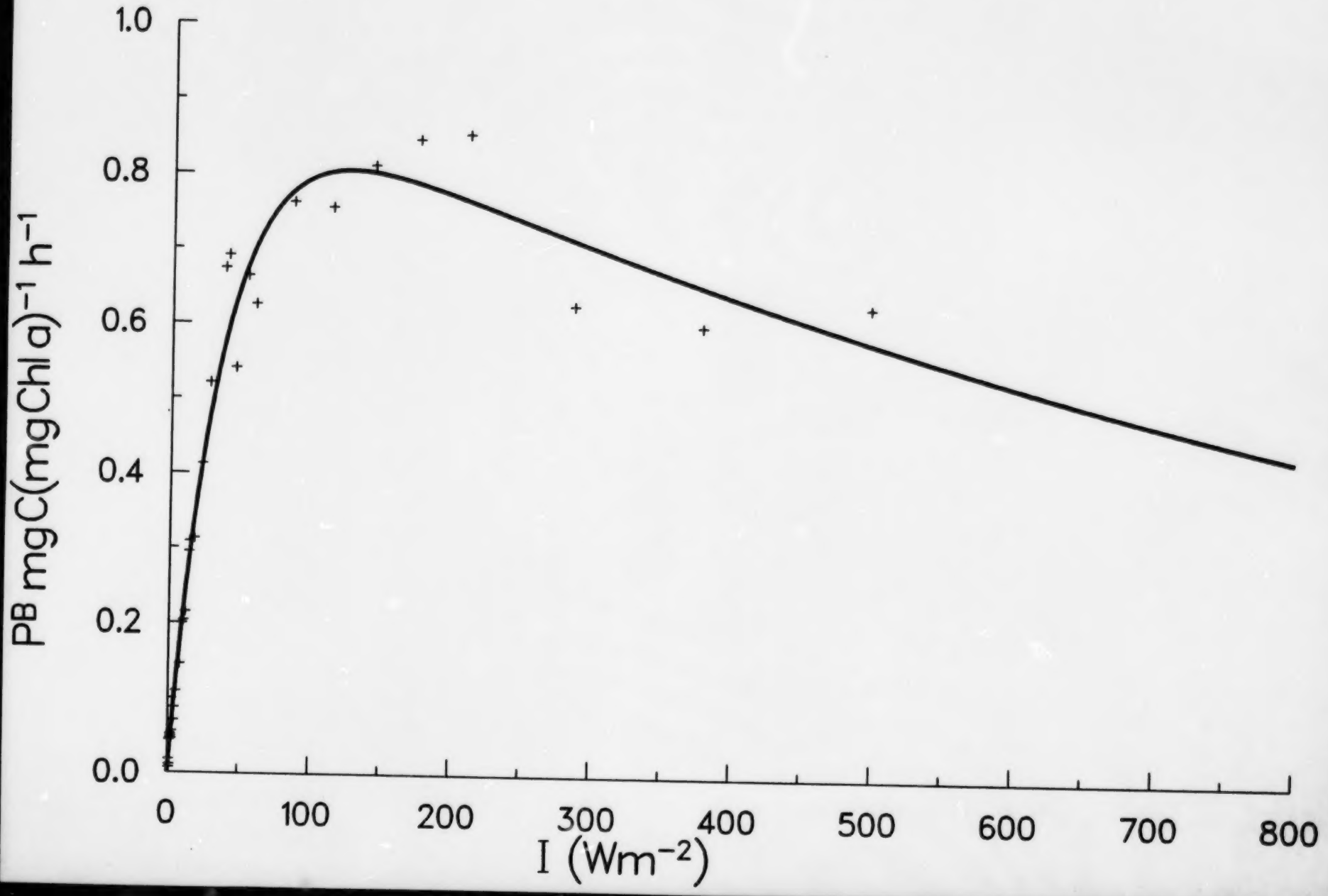

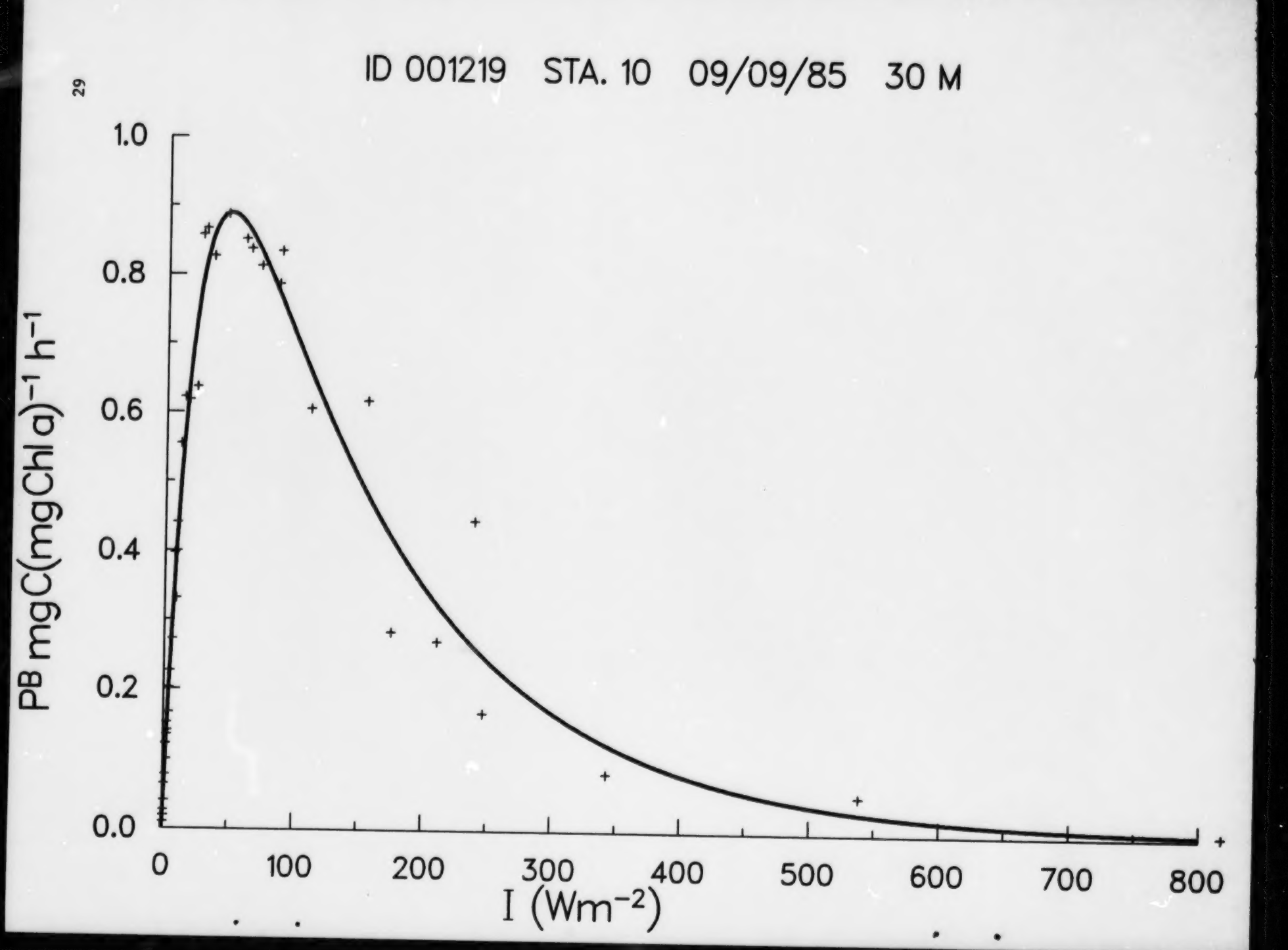
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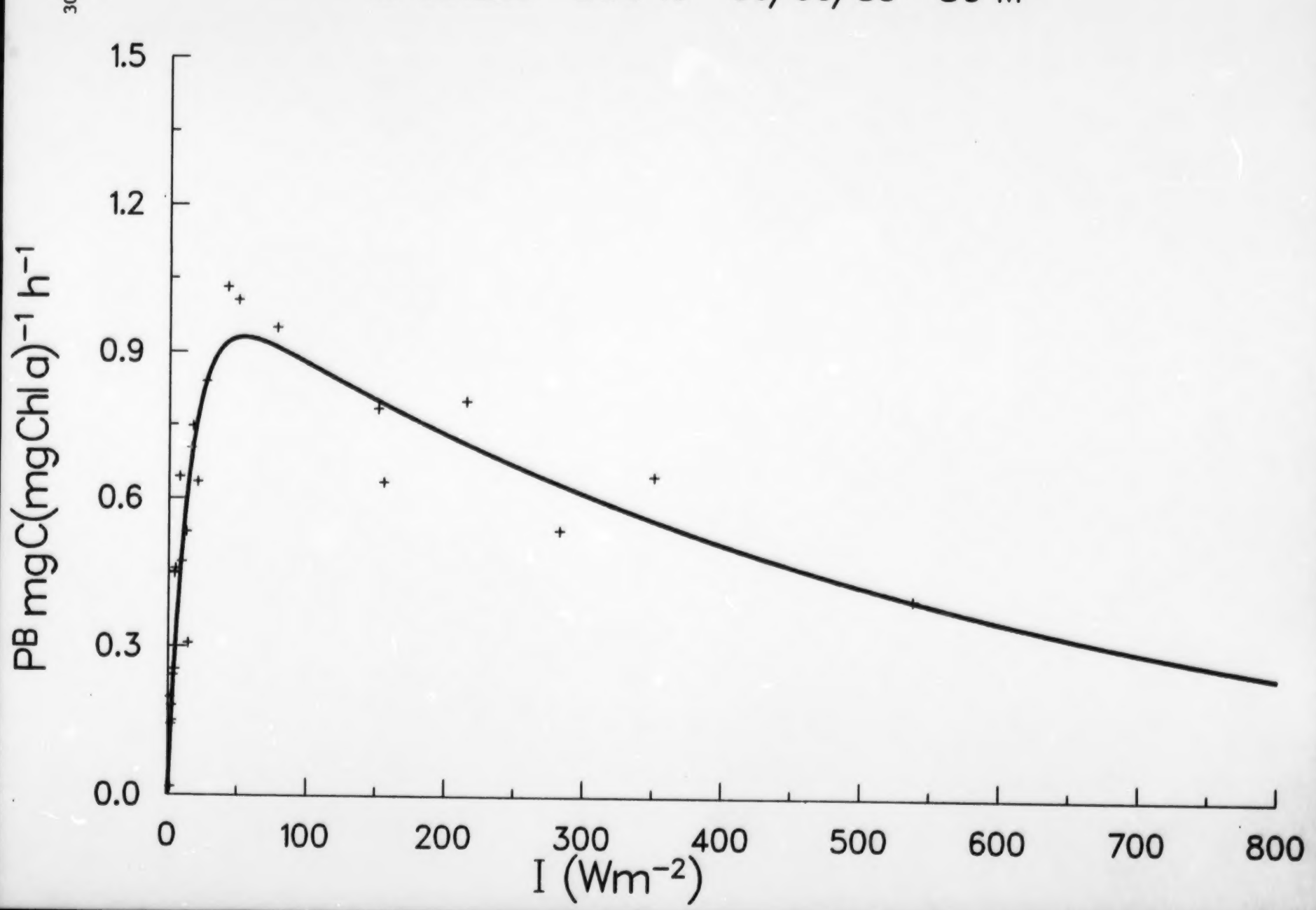
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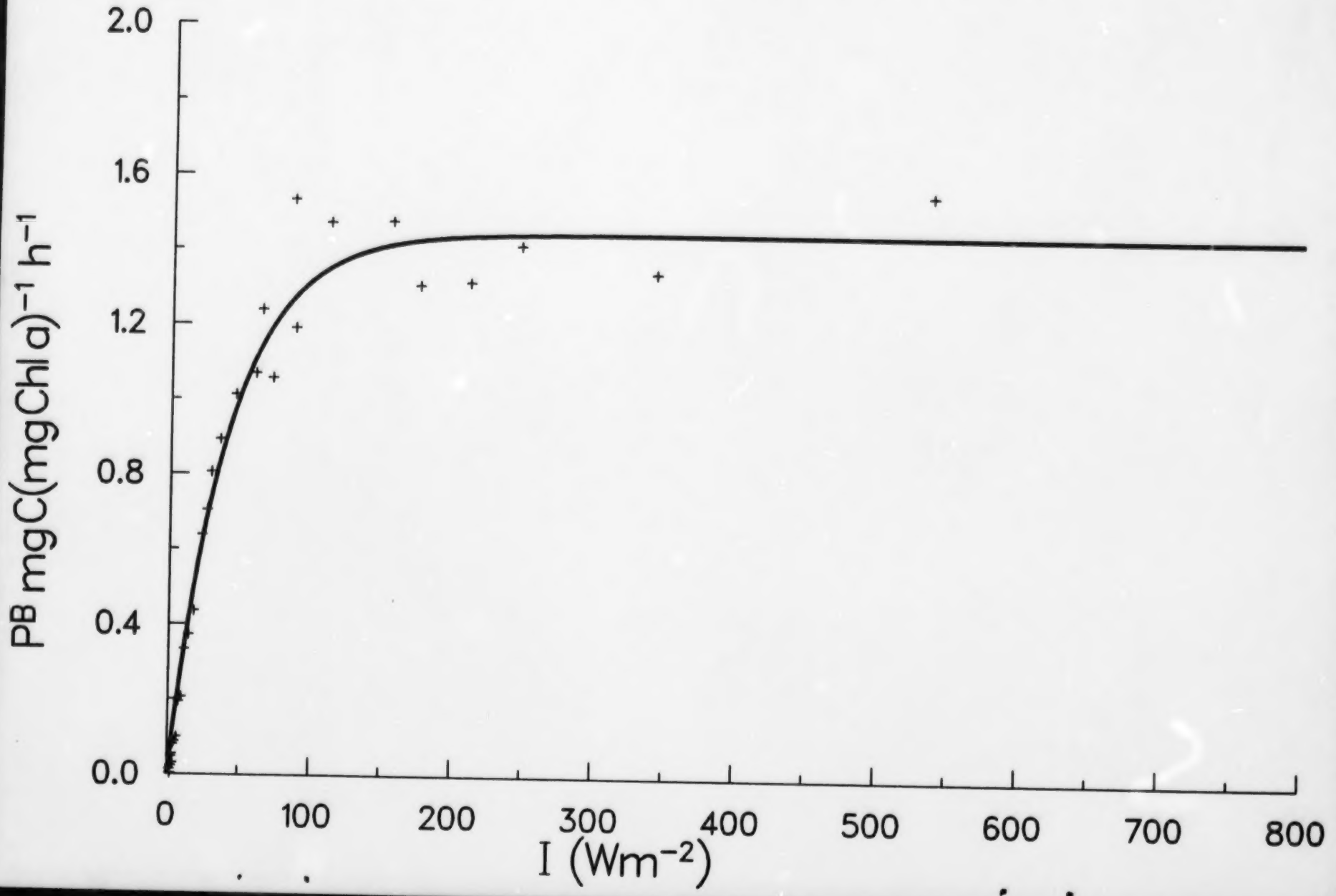

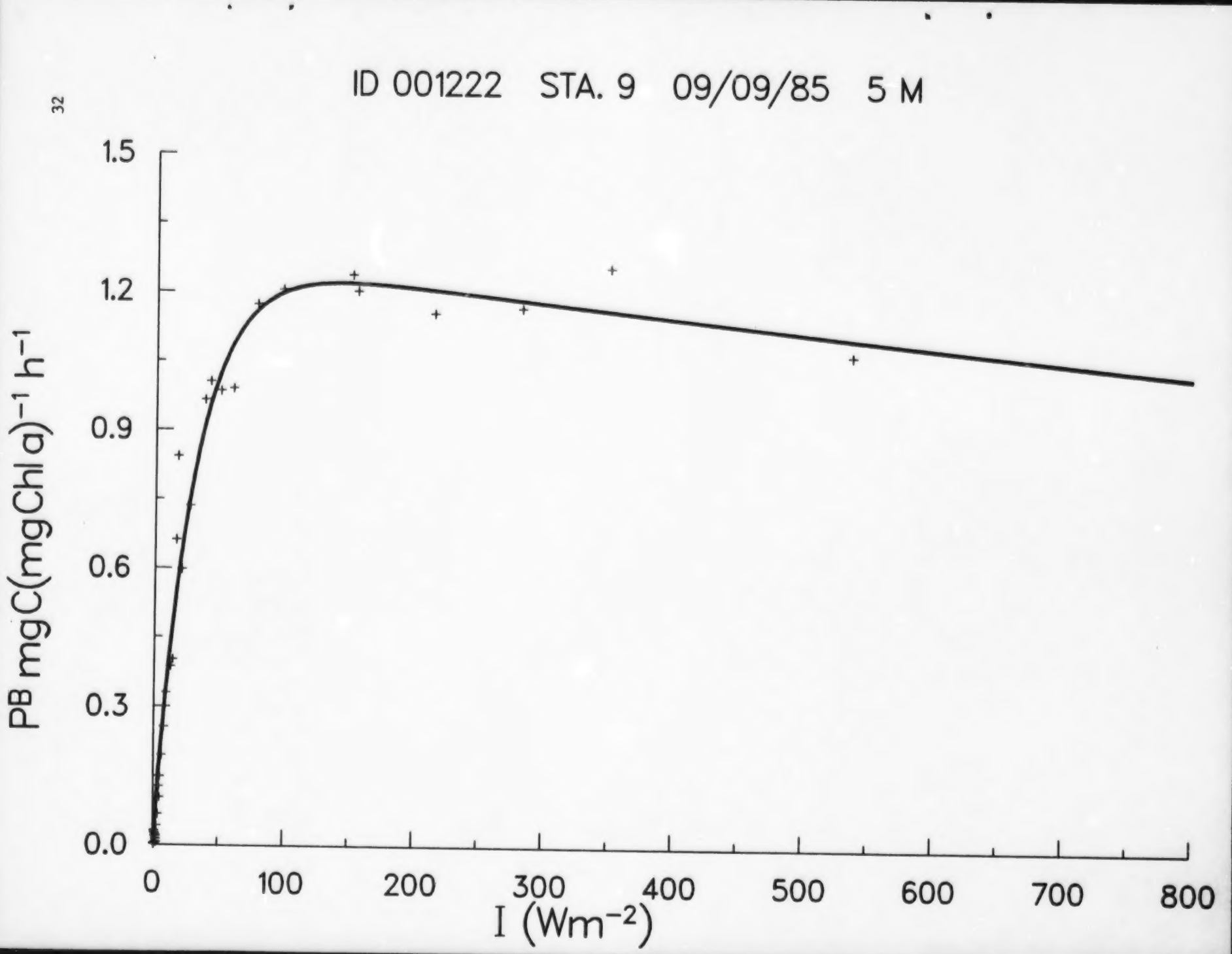
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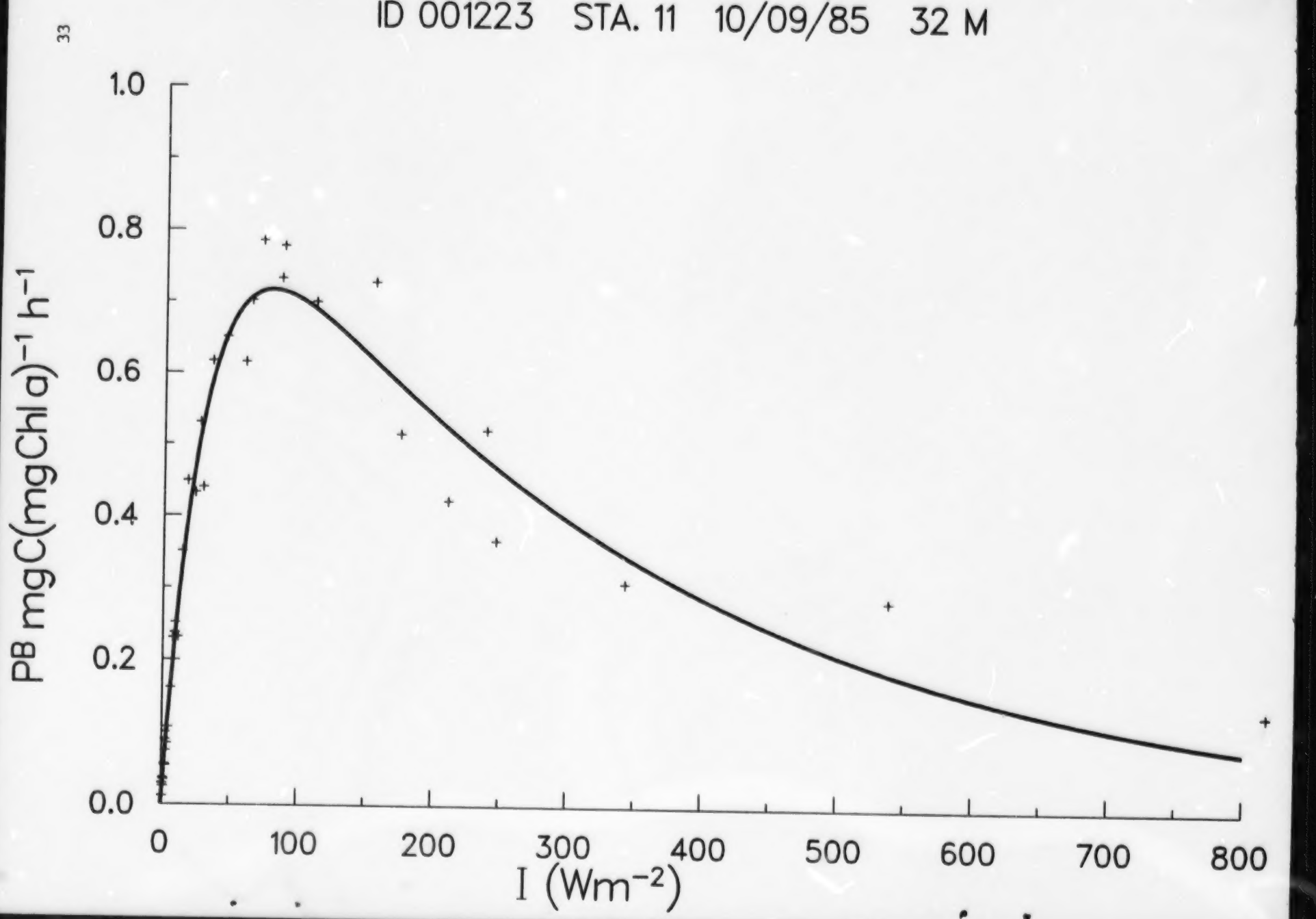
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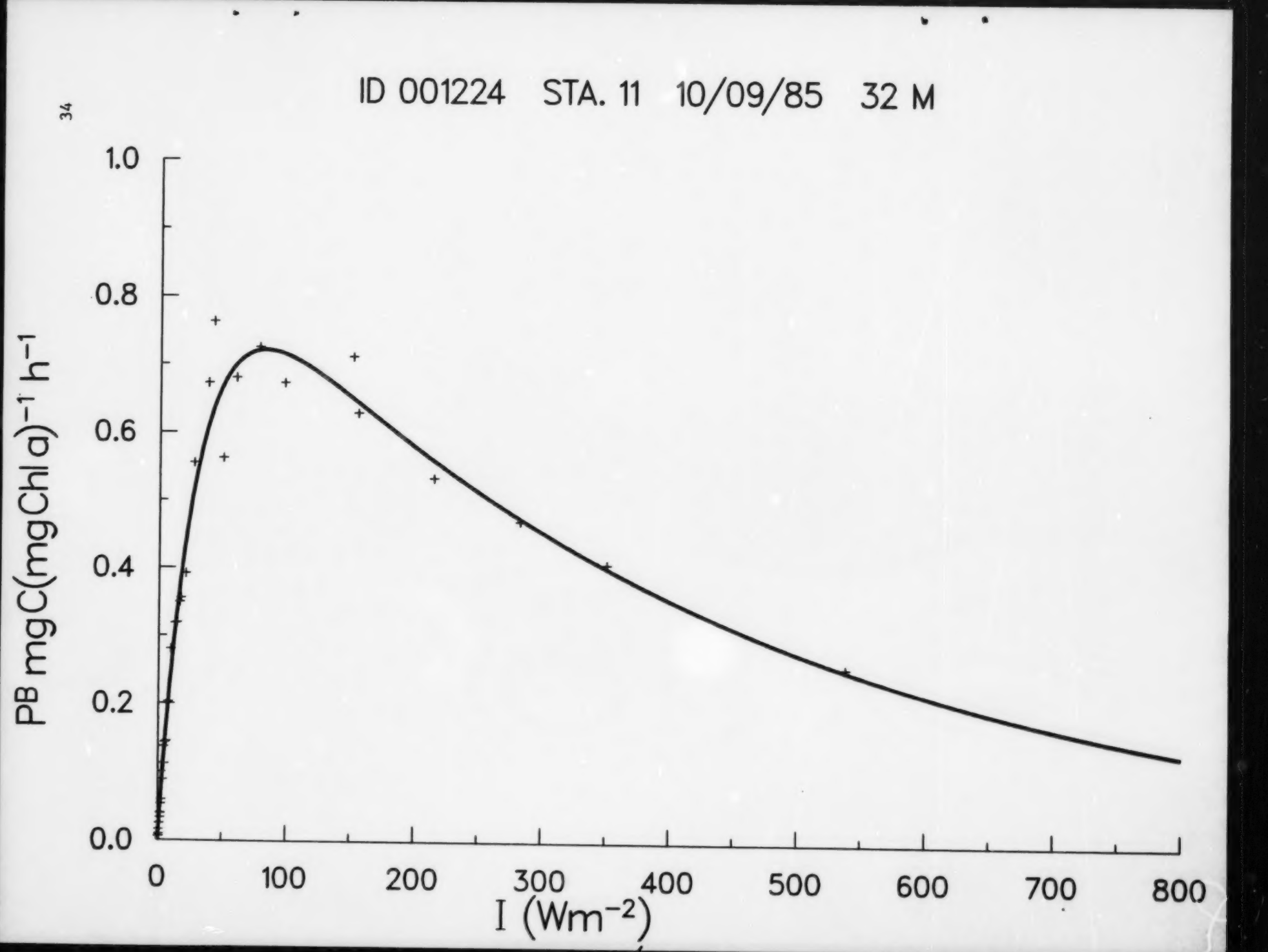
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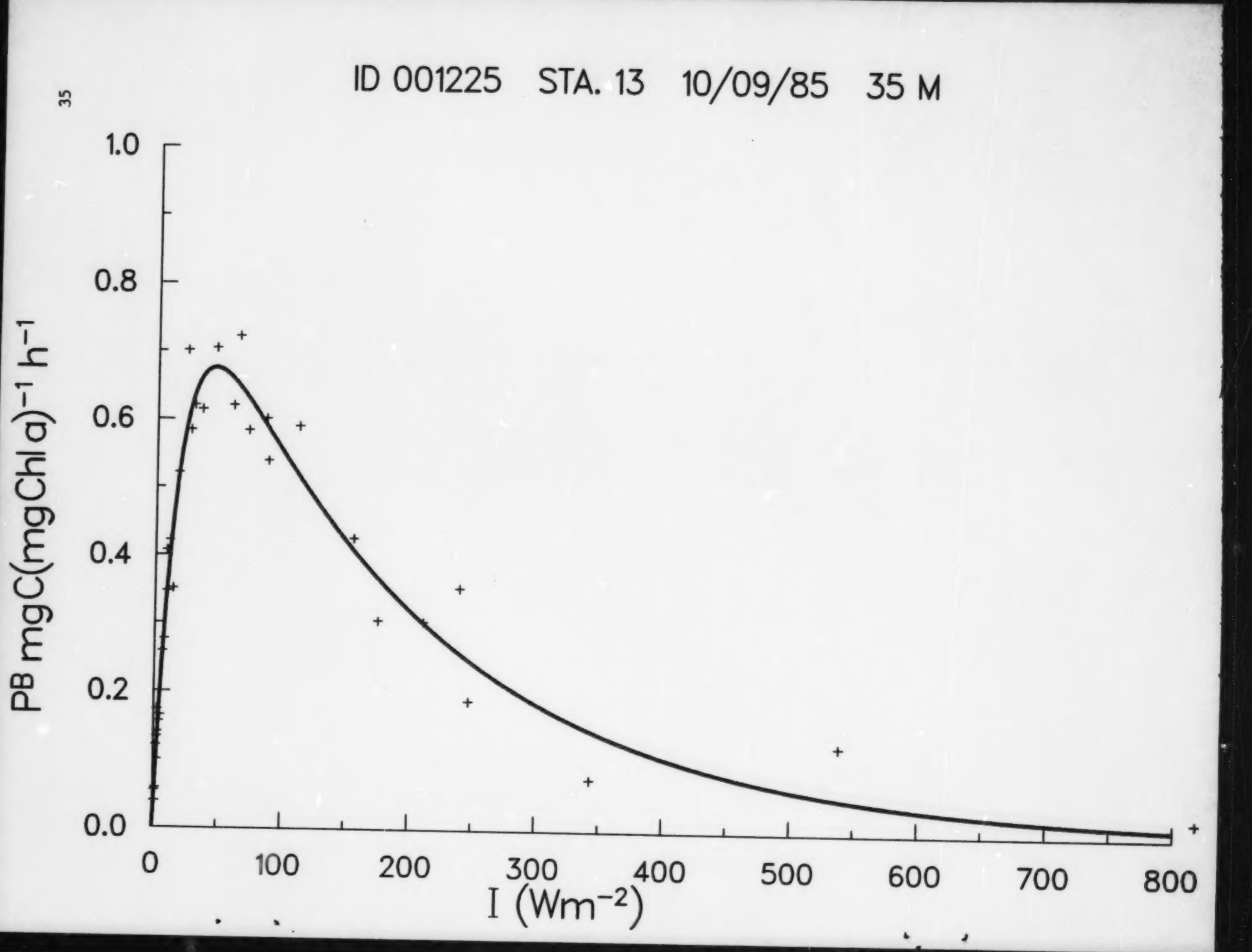
PB mgC(mgChl a)$^{-1}$ h^{-1}
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
600
700
800
I (Wm^{-2})


ID 001225 STA. 13 10/09/85 35 M
1.0
0.8
0.6
0.4
0.2
0.0
PB mgC(mgChl a)$^{-1}$ h^{-1}
0
100
200
300
400
500
600
700
800
I (Wm^{-2})

PROFILE DATA

UNITS

T	=	°C
Sal	=	0/00
NO_3	=	mg at m^{-3}
SIO^3	=	mg at m^{-3}
PO_4	=	mg at m^{-3}
NH_3	=	mg at m^{-3}
Chl	=	mg m^{-3}
POC	=	mg m^{-3}
PON	=	mg m^{-3}

GRAND BANKS 1985

LAT 46° 4.84' N LONG 55°27.98' W DATE 04/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	11.44	31.83	.10	.91	.28	.67	-	216	13
5	11.46	31.82	.05	.93	.25	.66	-	186	17
10	11.44	31.82	.45	.64	.13	.63	-	142	13
15	11.38	31.82	.05	.94	.20	.63	-	148	12
20	11.19	31.81	.05	.86	.24	1.16	-	154	15
25	7.56	32.02	.06	1.04	.33	1.10	-	149	15
30	1.85	32.44	.36	2.13	.46	1.20	-	114	12
40	-.14	32.65	1.95	3.69	.63	.36	-	62	6
50	-.37	32.69	2.58	4.30	.70	.21	-	46	9
60	-.50	32.73	-	-	-	-	-	-	-

GRAND BANKS 1985

LAT 45°47.21' N LONG 54°32.29' W DATE 05/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	10.90	31.99	.24	.00	.24	.42	.26	139	11
5	10.87	31.92	.06	.44	.12	.41	.25	137	11
10	10.69	32.00	.18	.49	.21	.40	.30	134	12
15	10.65	31.99	.26	.55	.17	.45	.18	142	16
20	9.67	32.15	.28	.63	.02	1.03	.16	149	9
25	4.33	32.46	.57	.98	.10	1.66	.39	160	17
30	.91	32.87	.69	.83	.42	1.12	.28	102	8
40	-.04	32.95	.44	1.15	.22	.62	.44	90	18
50	-.54	32.95	.62	1.12	.23	.64	.40	100	10
70	-1.56	33.20	5.94	4.84	.54	.08	-	46	4

GRAND BANKS 1985

LAT 45°28.00' N LONG 53°47.00' W DATE 05/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	12.90	31.98	.51	.14	.08	.42	.12	185	15
5	12.90	32.00	.23	.44	.18	.43	.28	137	20
10	12.88	31.99	.24	2.23	.21	.43	.28	126	13
15	12.88	32.00	.49	.38	.13	.49	.09	135	16
20	12.64	32.00	.45	1.99	.06	.77	.14	124	15
25	12.63	32.00	.74	.42	.10	.90	.12	121	15
30	9.07	31.94	.28	1.83	.10	1.01	.09	138	25
40	1.98	32.67	1.17	1.53	.36	.50	.47	68	7
50	.19	32.86	3.21	4.33	.39	.15	1.05	55	3
80	-1.54	33.37	7.80	12.27	.81	.06	-	64	6

GRAND BANKS 1985

LAT 45° 9.99' N LONG 53° 4.92' W DATE 06/08/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	12.82	32.00	.23	.34	.04	.52	.11	98	10
5	12.82	32.00	.56	.28	.07	.50	.05	94	9
10	12.82	32.02	.00	.58	.04	.51	.11	95	12
15	12.82	32.00	.58	.24	.07	.53	.07	89	10
20	12.06	32.03	.00	.43	.02	1.16	.12	124	14
25	4.98	32.53	.00	.81	.19	1.08	.14	127	15
30	2.57	32.62	.00	1.27	.29	.54	.44	56	4
40	1.12	32.68	.70	.79	.36	.28	.39	43	3
50	.22	32.81	2.60	2.86	.69	.20	2.26	45	-
70	-.50	33.03	3.90	6.18	.60	.06	-	29	-

GRAND BANKS 1985

LAT 44°48.10' N LONG 52°16.20' W DATE 06/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	13.78	31.93	.31	.54	.15	.30	-	125	12
5	13.77	31.94	.16	.49	.15	.23	-	98	9
10	13.75	31.94	.09	.59	.20	.24	-	88	8
15	13.64	31.89	.48	.24	.12	.28	-	108	10
20	9.31	32.05	.67	.00	.22	.55	-	134	12
25	4.44	32.41	.15	.98	.34	1.41	-	138	14
30	2.12	32.54	.41	1.53	.38	.81	-	68	4
40	1.44	32.59	.97	4.00	.56	.52	-	63	-
50	1.06	32.67	1.82	4.47	.57	.24	-	68	3
60	.54	32.89	4.71	9.15	.74	.09	-	51	-

GRAND BANKS 1985

LAT 44°30.20' N LONG 51°27.30' W DATE 07/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	13.70	31.97	.49	.10	.30	.25	.12	110	13
5	13.71	31.97	.28	.25	.30	.25	.02	129	12
10	13.71	31.97	.02	1.24	.37	.25	.05	107	9
15	13.72	31.98	.52	.30	.15	.33	.09	109	10
20	13.70	31.96	.43	.29	.15	.26	.11	143	25
25	8.94	32.05	.17	.50	.29	.68	.11	224	31
30	2.79	32.31	.01	1.16	.51	1.77	.42	186	23
40	1.62	32.58	.62	3.90	.78	.60	.97	105	10
50	1.33	32.63	1.55	5.14	.67	.24	1.53	53	3
60	1.31	32.64	1.75	5.61	.74	.21	-	74	4

GRAND BANKS 1985

LAT 44°10.10' N LONG 50°43.00' W DATE 07/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	13.90	32.09	.26	.41	.19	.28	-	99	9
5	13.90	32.10	.64	.39	.15	.29	-	96	9
10	13.90	32.11	.95	.15	.33	.28	-	108	8
15	13.87	32.09	.95	.59	.18	.31	-	107	16
20	13.84	32.10	1.28	.44	.16	.31	-	112	9
25	13.14	32.09	1.61	.28	.07	.34	-	132	15
30	5.35	32.34	.49	.29	.12	1.90	-	440	57
40	2.12	32.44	1.54	1.74	.49	.49	-	91	3
50	2.05	32.46	1.26	2.46	.41	.44	-	64	3
55	2.06	32.46	1.27	2.43	.32	.40	-	68	4

GRAND BANKS 1985

LAT 44° .10' N LONG 50°20.00' W DATE 07/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	13.62	32.27	.85	.45	.28	.63	-	144	16
5	13.64	32.26	.18	.73	.33	.59	-	-	-
10	13.60	32.26	.11	.68	.35	.56	-	-	-
15	13.57	32.28	.18	.86	.29	.55	-	-	-
20	12.96	32.29	.81	.79	.18	.65	-	-	-
25	12.67	32.24	.15	.49	.36	1.05	-	-	-
30	2.56	32.81	1.80	2.77	.89	.28	-	-	-
40	2.61	32.83	1.45	2.08	.71	.18	-	68	5
50	2.65	32.84	2.33	2.81	.68	.15	-	-	-

GRAND BANKS 1985

LAT 44°38.07' N LONG 50°20.00' W DATE 08/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	11.24	32.22	.09	.37	.21	.26	.12	102	13
5	10.93	32.08	.30	.16	.14	.28	.09	96	12
10	10.18	32.12	.33	.28	.19	.32	.11	75	8
15	10.19	32.14	.45	.24	.17	.37	.16	82	6
20	9.79	32.37	.31	.58	.25	.66	.12	114	11
25	4.32	32.64	.56	1.02	.29	1.34	.23	198	20
30	1.00	32.96	3.77	3.11	.45	.62	.61	85	11
40	.86	32.96	.84	3.07	.33	.72	.61	104	8
45	.95	32.96	-	-	-	-	-	-	-

GRAND BANKS 1985

LAT 43°52.00' N LONG 49°55.00' W DATE 08/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	11.63	32.39	.00	.97	.12	.72	-	154	19
5	11.63	32.40	.00	1.21	.19	.72	-	149	21
10	11.61	32.41	.00	1.22	.20	.68	-	144	18
15	11.57	32.42	.00	.58	.20	.69	-	156	25
20	6.84	32.79	.00	2.01	.39	2.06	-	226	36
25	2.54	32.92	.27	4.32	.84	2.55	-	175	36
30	2.53	32.91	.46	4.36	.84	.98	-	106	23
40	2.53	32.91	.58	3.49	.62	.80	-	93	16

GRAND BANKS 1985

LAT 43°41.98' N LONG 49°29.80' W DATE 08/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	10.39	31.90	.00	.91	.10	.58	-	-	-
5	9.38	31.97	.00	1.01	.06	.58	-	-	-
10	7.20	32.30	.00	.91	.08	1.81	-	-	-
15	3.40	32.64	.00	1.72	.22	1.25	-	-	-
20	1.64	32.83	1.35	2.04	.21	2.73	-	-	-
25	.26	33.03	2.54	2.67	.35	2.08	-	-	-
30	-.22	33.08	2.35	3.15	.37	1.77	-	-	-
40	-.26	33.08	2.42	3.15	.37	1.79	-	-	-

GRAND BANKS 1985

LAT 43°35.00' N LONG 49° 7.00' W DATE 09/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
4	7.83	32.30	.00	1.25	.15	1.25	-	172	23
10	6.95	32.31	.00	.99	.10	1.92	-	198	28
15	4.88	32.50	.14	.64	.14	5.42	-	330	43
20	2.36	32.74	.36	1.60	.28	7.01	-	325	46
25	-.50	33.13	4.41	3.46	.63	2.03	-	117	14
30	-1.02	33.22	6.22	5.65	.79	.45	-	63	13
40	-1.14	33.25	6.77	6.08	.78	.40	-	63	12
60	-1.64	33.38	6.09	5.79	.73	.16	-	42	5
80	-1.58	33.49	6.99	6.69	.74	.08	-	43	5
100	-1.49	33.57	7.81	7.11	.76	.06	-	39	7

GRAND BANKS 1985

LAT 43°10.30' N LONG 48°22.70' W DATE 09/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
10	16.35	32.54	.00	.77	.06	.22	.14	83	17
20	15.51	33.04	.00	1.05	.17	1.01	.11	196	29
30	15.14	33.83	2.56	1.92	.41	2.60	.15	180	33
40	8.34	34.80	5.99	3.69	.48	.74	.10	66	12
50	8.07	34.81	6.29	3.50	.49	.15	.25	38	5
60	8.00	34.81	7.85	4.46	.65	.08	.07	28	5
70	7.88	34.80	8.54	4.98	.72	.06	.12	26	4
80	7.57	34.79	9.38	5.40	.72	.06	.15	29	2
90	7.16	34.77	10.62	6.24	.81	.04	.21	42	3
100	7.41	34.86	12.11	7.22	.83	.03	–	24	2

GRAND BANKS 1985

LAT 43°43.00' N LONG 50°32.00' W DATE 10/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	14.47	32.02	.09	.46	.27	.32	.07	94	11
5	14.47	32.02	.09	.49	.31	.32	.07	111	14
10	14.47	32.03	.08	.37	.28	.33	.13	212	30
15	14.47	32.02	.06	.37	.24	.33	.08	118	14
20	14.44	31.90	.09	.31	.22	.36	.15	99	15
25	6.27	32.30	.11	.20	.32	.64	.18	237	29
30	2.47	32.44	.33	1.81	.59	1.72	.49	251	36
40	2.22	32.49	.49	2.72	.57	.62	1.00	195	25
50	2.23	32.65	1.20	5.38	.95	.52	1.56	226	18
55	2.23	32.66	-	-	-	-	-	-	-

GRAND BANKS 1985

LAT 43°25.00' N LONG 50°47.00' W DATE 10/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	14.08	32.25	.31	.73	.23	.28	-	137	19
5	14.02	32.26	.10	.79	.35	.32	-	142	23
10	14.00	32.26	.04	.91	.50	.31	-	166	15
15	13.90	32.26	1.14	.88	.55	.32	-	142	15
20	12.26	32.25	.33	1.06	.32	.38	-	194	21
25	8.15	32.44	.35	1.71	.38	.81	-	268	32
30	2.90	32.74	.92	4.88	.73	1.59	-	149	14
40	1.35	32.97	1.38	6.07	.85	1.19	-	139	9
50	.67	33.05	1.75	6.21	.87	.87	-	126	7
55	.13	33.13	1.89	5.76	.69	.34	-	662	46

GRAND BANKS 1985

LAT 43° 5.00' N LONG 50°59.90' W DATE 10/09/1985

Z	TEMP	SAL	NO3	SIO3	PO4	CHL	NH3	POC	PON
1	16.77	32.63	.36	.42	.03	.21	-	-	-
5	16.60	32.63	.09	.20	.08	.22	-	-	-
10	16.49	32.63	.32	.13	.22	.21	-	108	13
15	16.47	32.63	.00	.83	.02	.23	-	121	14
20	16.61	32.83	.00	.77	.05	.29	-	116	13
25	14.29	32.74	.00	1.06	.14	.57	-	156	19
30	7.73	32.87	.00	1.19	.23	1.14	-	179	23
35	4.88	33.00	.00	1.07	.12	1.52	-	155	20
50	3.73	33.41	3.43	1.78	.31	.23	-	73	5
100	7.77	34.76	12.38	6.12	.64	.04	-	56	4

PI DATA

GRAND BANKS 1985

LAT 44°38.07' N LONG 50° .20' W DATE 08/09/1985 DEPTH 25 M

I	P	I	P	I	P	I	P
498	.41	379	.72	287	.81	211	.92
175	.97	144	.87	114	.98	60	.83
54	.85	46	.72	40	.73	37	.75
28	.63	23	.51	18	.36	14	.25
14	.34	12	.25	10	.26	8	.20
7	.14	5	.11	5	.10	4	.08
3	.05	2	.04	2	.03	2	.03
2	.02	1	.02	1	.02	1	.01

PARAMETER VALUES

PS : 1.42 (1.31, 1.52)

ALPHA : .027 (.026, .029)

BETA : .0030 (.0024, .0036)

SAMPLE TEMP 4.3°C

INCUBATION TEMP .3°C

CHLOROPHYLL : 1.34

AMMONIA : .23

NITROGEN : 20

CARBON : 198

NITRATE : .56

SILICATE : 1.02

PHOSPHATE : .29

SALINITY : 32.64

GRAND BANKS 1985

LAT 43°52.00' N LONG 49°54.80' W DATE 08/09/1985 DEPTH 20 M

I	P	I	P	I	P	I	P
817	.41	538	.53	419	.67	327	.73
243	.81	124	.82	104	.79	96	.73
84	.75	76	.79	64	.75	46	.55
36	.47	30	.47	27	.50	26	.27
17	.24	13	.19	10	.15	10	.10
8	.12	7	.11	5	.04	4	.03
4	.03	3	.04	3	.02	3	.03
2	.01	2	.00	1	.00	1	.00

PARAMETER VALUES

PS : 1.14 (1.06, 1.22)

ALPHA : .018 (.017, .019)

BETA : .0015 (.0012, .0018)

SAMPLE TEMP 6.8°C

INCUBATION TEMP .8°C

CHLOROPHYLL : 2.06

AMMONIA : -99.00

NITROGEN : 36

CARBON : 226

NITRATE : .00

SILICATE : 2.01

PHOSPHATE : .39

SALINITY : 32.79

GRAND BANKS 1985

LAT 43°52.00' N LONG 49°54.80' W DATE 08/09/1985 DEPTH 40 M

I	P	I	P	I	P	I	P
498	.63	379	.60	287	.63	211	.85
175	.85	144	.81	114	.76	86	.76
60	.63	54	.66	46	.54	40	.69
37	.67	28	.52	23	.41	18	.31
14	.31	14	.30	12	.22	10	.20
8	.15	5	.11	5	.09	4	.07
3	.06	2	.05	2	.05	2	.05
2	.05	1	.01	1	.04	1	.02
.8	.01						

PARAMETER VALUES

PS : .94 (.89, 1.00)

ALPHA : .025 (.023, .026)

BETA : .0009 (.0007, .0012)

SAMPLE TEMP 2.5°C

INCUBATION TEMP .5°C

CHLOROPHYLL : .80

AMMONIA : -99.00

NITROGEN : 16

CARBON : 93

NITRATE : .58

SILICATE : 3.49

PHOSPHATE : .62

SALINITY : 32.91

GRAND BANKS 1985

LAT 43° 9.96' N LONG 48°22.97' W DATE 09/09/1985 DEPTH 30 M

I	P	I	P	I	P	I	P
817	.01	538	.05	343	.08	247	.17
239	.45	211	.27	175	.28	155	.62
112	.61	88	.84	86	.79	72	.81
64	.84	60	.85	46	.89	35	.83
29	.87	26	.86	23	.64	18	.62
14	.62	11	.56	9	.44	9	.33
8	.40	6	.27	5	.23	4	.17
4	.20	3	.14	3	.15	3	.14
2	.12	2	.08	1	.04	1	.07
1	.03	1	.02	.7	.01		

PARAMETER VALUES

PS : 1.50	ALPHA : .057	BETA : .0109
(1.36, 1.64)	(.054, .060)	(.0088, .0130)

SAMPLE TEMP 5.1°C INCUBATION TEMP .1°C

CHLOROPHYLL	1.25	NITRATE	.00
AMMONIA	-99.00	SILICATE	1.25
NITROGEN	23	PHOSPHATE	.15
CARBON	172	SALINITY	32.30

GRAND BANKS 1985

LAT 43° 9.96' N LONG 48°22.97' W DATE 09/09/1985 DEPTH 80 M

I	P	I	P	I	P	I	P
538	.40	351	.65	283	.54	215	.80
155	.64	151	.79	78	.95	50	1.01
42	1.03	27	.84	21	.63	17	.75
16	.70	14	.31	13	.53	10	.47
8	.64	5	.46	5	.25	4	.45
4	.24	3	.18	2	.14	2	.02
2	.20						

PARAMETER VALUES

PS : 1.05 (.95, 1.16)

ALPHA : .071 (.062, .080)

BETA : .0019 (.0012, .0026)

SAMPLE TEMP 7.6°C

INCUBATION TEMP .6°C

CHLOROPHYLL : 1.25

AMMONIA : -99.00

NITROGEN : 23

CARBON : 172

NITRATE : .00

SILICATE : 1.25

PHOSPHATE : .15

SALINITY : 32.30

GRAND BANKS 1985

LAT 43°35.10' N LONG 49° 7.00' W DATE 09/09/1985 DEPTH 5 M

I	P	I	P	I	P	I	P
538	1.55	343	1.34	247	1.41	211	1.31
175	1.30	155	1.48	112	1.47	88	1.19
86	1.53	72	1.06	64	1.24	60	1.07
46	1.01	35	.89	29	.81	26	.70
23	.64	18	.44	14	.37	11	.34
9	.21	9	.21	8	.19	6	.10
5	.09	4	.03	4	.08	3	.05
3	.02	3	.05	2	.00	2	.01

PARAMETER VALUES

PS : 1.44	ALPHA : .035	BETA : .0000
(1.36, 1.53)	(.033, .038)	(-.0003, .0003)

SAMPLE TEMP 7.8°C INCUBATION TEMP .8°C

CHLOROPHYLL	2.60	NITRATE	2.56
AMMONIA	.15	SILICATE	1.92
NITROGEN	33	PHOSPHATE	.41
CARBON	180	SALINITY	33.83

GRAND BANKS 1985

LAT 43°35.10' N LONG 49° 7.00' W DATE 09/09/1985 DEPTH 5 M

I	P	I	P	I	P	I	P
538	1.07	351	1.25	283	1.17	215	1.15
155	1.20	151	1.24	98	1.21	78	1.17
60	.99	50	.99	42	1.01	38	.97
27	.74	21	.60	17	.84	16	.66
14	.40	13	.39	10	.33	8	.26
6	.20	5	.15	5	.10	4	.13
4	.07	3	.04	2	.01	2	.01
2	.02	2	.02	1	.03	1	.03
.9	.00	.7	.00				

PARAMETER VALUES

PS : 1.28
(1.21, 1.34)

ALPHA : .043
(.040, .045)

BETA : .0004
(.0001, .0006)

SAMPLE TEMP 4.8°C

INCUBATION TEMP .8°C

CHLOROPHYLL : .06

AMMONIA : .15

NITROGEN : 2

CARBON : 29

NITRATE : 9.38

SILICATE : 5.40

PHOSPHATE : .72

SALINITY : 34.79

GRAND BANKS 1985

LAT 43°43.00' N LONG 50°32.14' W DATE 10/09/1985 DEPTH 32 M

I	P	I	P	I	P	I	P
817	.14	538	.29	343	.31	247	.37
239	.52	211	.42	175	.52	155	.73
112	.70	88	.78	86	.73	72	.79
64	.70	60	.62	46	.65	35	.62
29	.44	26	.53	23	.43	18	.45
14	.35	11	.23	9	.25	9	.24
8	.23	6	.16	5	.11	4	.09
4	.11	3	.08	3	.09	3	.05
2	.06	2	.04	1	.03	1	.04
1	.03	1	.01				

PARAMETER VALUES

PS : 1.02 (.94, 1.10)

ALPHA : .030 (.028, .032)

BETA : .0032 (.0026, .0038)

SAMPLE TEMP 2.4°C

INCUBATION TEMP .4°C

CHLOROPHYLL : 1.72

AMMONIA : .49

NITROGEN : 36

CARBON : 251

NITRATE : .33

SILICATE : 1.81

PHOSPHATE : .59

SALINITY : 32.44

GRAND BANKS 1985

LAT 43°43.00' N LONG 50°32.14' W DATE 10/09/1985 DEPTH 32 M

I	P	I	P	I	P	I	P
538	.26	351	.41	283	.47	215	.53
155	.63	151	.71	98	.67	78	.73
60	.68	50	.56	42	.76	38	.67
27	.56	21	.39	17	.36	16	.35
14	.32	13	.32	10	.28	8	.20
6	.15	5	.14	5	.11	4	.14
4	.09	3	.06	2	.05	2	.04
2	.04	2	.03	1	.03	1	.02
.9	.01	.7	.01				

PARAMETER VALUES

PS : .95 (.90, 1.01)

ALPHA : .030 (.029, .032)

BETA : .0023 (.0019, .0027)

SAMPLE TEMP 2.4°C

INCUBATION TEMP .4°C

CHLOROPHYLL : 1.72

AMMONIA : .49

NITROGEN : 36

CARBON : 251

NITRATE : .33

SILICATE : 1.81

PHOSPHATE : .59

SALINITY : 32.44

GRAND BANKS 1985

LAT 43° 5.00' N LONG 50°59.90' W DATE 10/09/1985 DEPTH 35 M

I	P	I	P	I	P	I	P
817	.02	538	.13	343	.08	247	.19
239	.35	211	.30	175	.31	155	.43
112	.59	88	.54	86	.60	72	.59
64	.72	60	.62	46	.71	35	.62
29	.62	26	.59	23	.70	18	.52
14	.35	11	.42	9	.35	9	.41
8	.28	6	.26	5	.17	4	.16
3	.14	3	.13	3	.17	2	.12
2	.06	1	.04	1	.06		

PARAMETER VALUES

PS : .96 (.89, 1.02)

ALPHA : .050 (.047, .053)

BETA : .0052 (.0043, .0061)

SAMPLE TEMP 4.9°C

INCUBATION TEMP .9°C

CHLOROPHYLL : 1.52

AMMONIA : -99.00

NITROGEN : 20

CARBON : 155

NITRATE : .00

SILICATE : 1.07

PHOSPHATE : .12

SALINITY : 33.00

GRAND BANKS 1985

LAT 45°47.21' N LONG 54°32.29' W DATE 05/09/1985 DEPTH 5 M

I	P	I	P	I	P	I	P
738	1.57	678	1.64	578	1.53	498	1.45
379	1.32	359	1.55	247	1.42	191	1.56
155	1.60	144	1.45	132	1.46	116	1.31
86	1.21	70	1.13	62	1.11	58	.91
52	.86	50	.79	26	.65	20	.49
18	.39	16	.38	15	.27	14	.27
9	.26	7	.19	7	.10	6	.06
5	.06	5	.08	4	.05	4	.03
4	.00						

PARAMETER VALUES

PS : 1.55 (1.48, 1.63)

ALPHA : .027 (.025, .028)

BETA : .0000 (-.0001, .0002)

SAMPLE TEMP 10.9°C

INCUBATION TEMP 11.0°C

CHLOROPHYLL : .41

AMMONIA : .25

NITROGEN : 11

CARBON : 137

NITRATE : .06

SILICATE : .44

PHOSPHATE : .12

SALINITY : 31.92

GRAND BANKS 1985

LAT 45°47.21' N LONG 54°32.29' W DATE 05/09/1985 DEPTH 25 M

I	P	I	P	I	P	I	P
395	.73	327	.75	291	.69	231	.70
207	.69	114	.64	84	.63	78	.52
70	.51	44	.55	33	.48	30	.40
28	.33	23	.31	22	.25	17	.29
13	.21	12	.18	11	.12	10	.11
9	.09	5	.07	4	.06	4	.04
4	.02	3	.02	3	.02	2	.01
2	.02	1	.01	1	.00	1	.00

PARAMETER VALUES

PS : .70	ALPHA : .017	BETA : .0000
(.65, .76)	(.016, .018)	(-.0002, .0002)

SAMPLE TEMP 4.3°C INCUBATION TEMP .1°C

CHLOROPHYLL :	1.03	NITRATE :	.28
AMMONIA :	.16	SILICATE :	.63
NITROGEN :	9	PHOSPHATE :	.02
CARBON :	149	SALINITY :	32.15

GRAND BANKS 1985

LAT 45°28.00' N LONG 53°47.00' W DATE 05/09/1985 DEPTH 10 M

I	P	I	P	I	P	I	P
678	1.65	578	1.51	379	1.55	359	1.35
191	1.49	144	1.46	132	1.42	116	1.36
86	1.28	70	1.16	62	1.11	58	.92
52	1.02	50	.95	26	.49	20	.45
18	.42	16	.26	15	.26	14	.28
9	.17	7	.19	7	.14	6	.11
5	.07	5	.06	4	.05	4	.07
4	.01						

PARAMETER VALUES

PS : 1.55	ALPHA : .027	BETA : .0000
(1.47, 1.64)	(.026, .029)	(-.0002, .0002)

SAMPLE TEMP 12.9°C INCUBATION TEMP 12.9°C

CHLOROPHYLL	: .43	NITRATE	: .24
AMMONIA	: .28	SILICATE	: 2.23
NITROGEN	: 13	PHOSPHATE	: .21
CARBON	: 126	SALINITY	: 31.99

GRAND BANKS 1985

LAT 45°28.00' N LONG 53°47.00' W DATE 05/09/1985 DEPTH 30 M

I	P	I	P	I	P	I	P
498	1.41	395	1.56	327	1.48	291	1.57
231	1.52	207	1.43	114	1.45	94	1.39
84	1.32	78	1.31	70	1.03	44	.94
33	.90	30	.98	28	.56	23	.61
22	.49	17	.45	13	.40	12	.34
11	.26	10	.23	9	.20	5	.11
4	.11	4	.07	4	.07	3	.04
3	.05	2	.02	2	.03		

PARAMETER VALUES

PS : 1.63	ALPHA : .032	BETA : .0004
(1.51, 1.74)	(.031, .034)	(.0000, .0008)

SAMPLE TEMP 9.1°C INCUBATION TEMP .0°C

CHLOROPHYLL	1.01	NITRATE	.28
AMMONIA	.09	SILICATE	1.83
NITROGEN	25	PHOSPHATE	.10
CARBON	138	SALINITY	31.94

GRAND BANKS 1985

LAT 45° 9.99' N LONG 53° 4.92' W DATE 06/09/1985 DEPTH 15 M

I	P	I	P	I	P	I	P
837	4.53	558	4.73	255	4.95	247	5.21
239	4.69	175	4.91	167	5.38	159	4.95
144	4.99	112	4.17	100	4.45	88	4.48
72	4.63	60	3.81	48	3.64	40	3.03
32	3.09	26	1.96	21	1.71	18	1.22
16	1.48	15	.92	12	.90	10	.77
8	.53	7	.40	6	.34	5	.28
5	.21	4	.24	3	.19	3	.08
2	.12	1	.03	1	.06	.9	.02

PARAMETER VALUES

PS : 5.41 (5.21, 5.62)

ALPHA : .107 (.101, .112)

BETA : .0013 (.0007, .0018)

SAMPLE TEMP 12.8°C

INCUBATION TEMP 12.9°C

CHLOROPHYLL : .53

AMMONIA : .07

NITROGEN : 10

CARBON : 89

NITRATE : .58

SILICATE : .24

PHOSPHATE : .07

SALINITY : 32.00

GRAND BANKS 1985

LAT 45° 9.99' N LONG 53° 4.92' W DATE 06/09/1985 DEPTH 40 M

I	P	I	P	I	P	I	P
399	.72	199	.91	159	.85	140	1.25
136	.91	100	1.37	80	1.39	60	1.25
46	1.07	37	1.00	24	.98	21	.63
20	.80	16	.62	16	.58	12	.52
11	.57	11	.46	9	.32	7	.29
7	.24	5	.23	3	.11	3	.06
2	.07	2	.05	2	.06	2	.05
2	.06						

PARAMETER VALUES

PS : 1.65	ALPHA : .052	BETA : .0044
(1.47, 1.83)	(.048, .056)	(.0028, .0059)

SAMPLE TEMP 1.1°C INCUBATION TEMP 2.0°C

CHLOROPHYLL	: .28	NITRATE	: .70
AMMONIA	: .39	SILICATE	: .79
NITROGEN	: 3	PHOSPHATE	: .36
CARBON	: 43	SALINITY	: 32.68

GRAND BANKS 1985

LAT 44°48.10' N LONG 52°16.20' W DATE 06/09/1985 DEPTH 20 M

I	P	I	P	I	P	I	P
837	.28	558	.31	439	.54	255	.94
247	1.22	175	1.34	167	1.34	144	1.23
112	1.22	100	1.33	72	1.15	60	1.00
48	1.10	32	.81	26	.81	21	.74
18	.64	16	.47	15	.43	12	.39
10	.32	8	.27	7	.22	6	.20
5	.16	5	.14	4	.16	3	.12
3	.08	3	.06	2	.06	2	.06
1	.02						

PARAMETER VALUES

PS : 2.19 (1.98, 2.39)

ALPHA : .036 (.035, .038)

BETA : .0065 (.0051, .0078)

SAMPLE TEMP 9.3°C

INCUBATION TEMP .3°C

CHLOROPHYLL : .55

AMMONIA : -99.00

NITROGEN : 12

CARBON : 134

NITRATE : .67

SILICATE : .00

PHOSPHATE : .22

SALINITY : 32.05

GRAND BANKS 1985

LAT 44°30.20' N LONG 51°27.30' W DATE 07/09/1985 DEPTH 1 M

I	P	I	P	I	P	I	P
817	3.82	538	3.85	419	3.99	327	3.92
267	3.93	259	3.54	243	3.76	151	3.78
124	3.78	104	3.38	96	3.50	84	3.19
76	3.48	64	3.00	46	2.52	36	2.10
30	2.28	27	1.58	26	1.02	17	.82
13	.95	10	.95	10	.55	8	.75
7	.61	6	.35	5	.20	4	.29
4	.37	3	.19	3	.18	3	.16
2	.22	2	.12	1	.11	1	.06
1	.10	1	.07	.7	.05	.4	.01

PARAMETER VALUES

PS : 3.96	ALPHA : .083	BETA : .0002
(3.82, 4.10)	(.079, .087)	(-.0001, .0005)

SAMPLE TEMP 13.7°C INCUBATION TEMP 13.7°C

CHLOROPHYLL	: .25	NITRATE	: .49
AMMONIA	: .12	SILICATE	: .10
NITROGEN	: 13	PHOSPHATE	: .30
CARBON	: 110	SALINITY	: 31.97

GRAND BANKS 1985

LAT 44°30.20' N LONG 51°27.30' W DATE 07/09/1985 DEPTH 30 M

I	P	I	P	I	P	I	P
498	.08	379	.10	287	.14	211	.20
175	.26	144	.25	114	.34	86	.31
60	.35	54	.32	46	.32	40	.27
28	.32	23	.28	18	.25	14	.30
14	.24	12	.24	10	.25	8	.22
7	.18	5	.14	5	.11	4	.10
3	.07	2	.05	2	.04	2	.03
2	.03	1	.02	1	.02	1	.02
.8	.01						

PARAMETER VALUES

PS : .39 (.37, .41)

ALPHA : .032 (.029, .034)

BETA : .0012 (.0010, .0014)

SAMPLE TEMP 2.8°C

INCUBATION TEMP .8°C

CHLOROPHYLL : 1.77

AMMONIA : .42

NITROGEN : 23

CARBON : 186

NITRATE : .01

SILICATE : 1.16

PHOSPHATE : .51

SALINITY : 32.31

GRAND BANKS 1985

LAT 44°10.10' N LONG 50°43.00' W DATE 07/09/1985 DEPTH 5 M

I	P	I	P	I	P	I	P
538	3.53	419	3.01	327	3.46	267	2.99
259	3.09	243	2.92	151	3.33	124	3.17
104	3.16	96	2.99	84	3.01	76	3.07
64	2.46	46	2.44	36	1.98	30	1.60
27	1.56	26	1.05	17	.87	13	.68
10	.56	10	.42	8	.58	7	.49
6	.32	5	.25	4	.05	4	.10
3	.10	3	.03	3	.10	2	.04
2	.13	1	.10	1	.07	1	.09

PARAMETER VALUES

PS : 3.39	ALPHA : .074	BETA : .0004
(3.19, 3.59)	(.070, .079)	(-.0003, .0010)

SAMPLE TEMP 13.9°C INCUBATION TEMP 13.9°C

CHLOROPHYLL	.29	NITRATE	.64
AMMONIA	-99.00	SILICATE	.39
NITROGEN	9	PHOSPHATE	.15
CARBON	96	SALINITY	32.10

GRAND BANKS 1985

LAT 44°10.10' N LONG 50°43.00' W DATE 07/09/1985 DEPTH 40 M

I	P	I	P	I	P	I	P
498	.19	379	.28	287	.40	211	.50
175	.57	144	.62	114	.67	86	.65
60	.63	54	.66	46	.54	14	.54
14	.47	12	.46	10	.46	8	.37
7	.29	5	.29	5	.27	4	.26
3	.19	2	.18	2	.09	2	.08
2	.06	1	.05	1	.07	1	.05
.8	.09	.6	.09	.6	.07	.6	.08
.4	.09	.3	.02	.2	.02	.2	.01
.1	.01						

PARAMETER VALUES

PS : .76 (.73, .79)

ALPHA : .065 (.061, .068)

BETA : .0017 (.0014, .0019)

SAMPLE TEMP 2.1°C

INCUBATION TEMP .1°C

CHLOROPHYLL : .49

AMMONIA : -99.00

NITROGEN : 3

CARBON : 91

NITRATE : 1.54

SILICATE : 1.74

PHOSPHATE : .49

SALINITY : 32.44

GRAND BANKS 1985

LAT 44° .10' N LONG 50°20.00' W DATE 07/09/1985 DEPTH 10 M

I	P	I	P	I	P	I	P
817	2.97	538	2.75	419	2.92	327	2.85
243	2.85	151	2.92	124	2.78	104	2.49
96	2.49	84	2.19	76	1.89	64	2.33
46	1.86	36	1.64	30	1.49	27	1.27
26	1.06	17	.89	13	.61	10	.58
10	.31	8	.40	7	.30	6	.21
5	.21	4	.08	4	.12	3	.08
3	.05	3	.08	2	.09	2	.03
1	.03	1	.01				

PARAMETER VALUES

PS : 2.91	ALPHA : .058	BETA : .0000
(2.79, 3.02)	(.055, .061)	(-.0002, .0003)

SAMPLE TEMP 13.6°C INCUBATION TEMP 13.6°C

CHLOROPHYLL :	.56	NITRATE :	.11
AMMONIA :	-99.00	SILICATE :	.68
NITROGEN :	-99	PHOSPHATE :	.35
CARBON :	-99	SALINITY :	32.26

GRAND BANKS 1985

LAT 44° .10' N LONG 50°20.00' W DATE 07/09/1985 DEPTH 15 M

I	P	I	P	I	P	I	P
498	2.21	379	2.35	287	2.47	175	2.18
144	1.99	114	2.19	86	1.97	60	1.58
54	1.41	46	1.20	40	1.16	37	1.12
28	.86	23	.59	18	.44	14	.43
14	.38	12	.36	10	.25	8	.17
7	.13	5	.13	5	.12	4	.19
3	.03	2	.03	2	.01	2	.01
2	.02	1	.01	1	.04	1	.01
.8	.02	.6	.03	.6	.03	.6	.02
.4	.02						

PARAMETER VALUES

PS : 2.79 (2.57, 3.01)

ALPHA : .036 (.035, .038)

BETA : .0013 (.0006, .0019)

SAMPLE TEMP 13.6°C

INCUBATION TEMP 13.6°C

CHLOROPHYLL : .55

AMMONIA : -99.00

NITROGEN : -99

CARBON : -99

NITRATE : .18

SILICATE : .86

PHOSPHATE : .29

SALINITY : 32.28

GRAND BANKS 1985

LAT 44°38.07' N LONG 50° .20' W DATE 08/09/1985 DEPTH 1 M

I	P	I	P	I	P	I	P
817	3.49	538	3.27	419	3.42	327	3.28
267	2.98	259	3.28	243	2.94	151	3.23
124	3.02	104	2.81	96	3.10	84	2.49
76	2.57	64	2.56	46	2.08	36	1.94
30	1.63	27	1.54	26	1.01	17	.87
13	.68	10	.54	10	.30	8	.42
7	.41	6	.19	5	.12	4	.08
4	.17	3	.12	3	.08	3	.10
2	.07	2	.01	1	.02		

PARAMETER VALUES

PS : 3.28 (3.15, 3.41)

ALPHA : .066 (.063, .070)

BETA : .0000 (-.0003, .0003)

SAMPLE TEMP 11.4°C

INCUBATION TEMP 11.4°C

CHLOROPHYLL : .26

AMMONIA : .12

NITROGEN : 13

CARBON : 102

NITRATE : .09

SILICATE : .37

PHOSPHATE : .21

SALINITY : 32.22